1993 Annual Report
East Hennepin Avenue Site
Minneapolis, Minnesota

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General Mills, Inc.

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1993 ANNUAL REPORT

EAST HENNEPIN AVENUE SITE

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1993 ANNUAL REPORT

EAST HENNEPIN AVENUE SITE

1.0 INTRODUCTION

This report summarizes the results from annual monitoring and remedial action operations conducted at the East Hennepin Avenue site during 1993. The 1993 monitoring was carried out in response to the requirements of Part II of Exhibit A to the October 23, 1984 Response Order by Consent between General Mills and the Minnesota Pollution Control Agency (MPCA); the January 1985 Groundwater Pump-out System Plan - East Hennepin Avenue Site; the Minnesota Department of Natural Resources Water Appropriation Permits (85-6144 and 85-6145); the Magnolia Member Aquifer Pump Test Report - Remedial Action Design Plan; the NPDES Permit MN 0056022; and, the 1993 Monitoring Plan.

The 1993 groundwater monitoring data (water levels and water quality) is provided in Section 2.0 of this report. The validity of the 1993 data is evaluated in Appendix A and is summarized in Section 3.0. Results of the 1993 monitoring are discussed in Section 5.0 along with an evaluation of historical trends in groundwater levels and water quality at the site. Historical data is presented in Appendix B. The effectiveness of the groundwater pump-out system is discussed in Section 6.0. Recommendations for activities at the site for 1994 are presented in Section 7.0. The Recommended 1994 Operation and Monitoring Plan is provided in Appendix C. Appendix D contains the Platteville Formation Pump-Out System Capture Zone Evaluation.

The East Hennepin Avenue site is located in Minneapolis, Minnesota as shown on the regional location map on Figure 1. A map of the site is shown on Figure 2. The generalized geologic column for the site is shown on Figure 3.

2.0 GROUNDWATER MONITORING

2.1 Water Level Monitoring

The 1993 monitoring program involved 72 measurements of water levels from 36 wells: 15 wells screened in the glacial drift (five pump-out wells and ten monitoring wells); 12 wells screened in the Carimona Member of the Platteville Formation (one pump-out well and 11 monitoring wells); five wells open to the Magnolia Member of the Platteville Formation (five monitoring wells); and, from four monitoring wells screened in the St. Peter Sandstone. All monitoring activities were carried out in accordance with the 1993 Monitoring Plan (see Appendix C of the 1992 Annual Report).

The results from 1993 water level monitoring are presented in Sections 2.1.1 through 2.1.4. Historical water elevation data for the glacial drift wells, Carimona Member wells, Magnolia Member wells, St. Peter wells, and pump-out wells is provided in Appendix B of this report.

2.1.1 Glacial Drift

Groundwater elevations were measured in glacial drift monitoring wells during the second (May) and fourth (November) quarter sampling events of 1993 at the locations shown on Figure 4. A summary of 1993 water level monitoring results is presented in Table 1. A cross section of the glacial drift groundwater surface for both monitoring periods is shown on Figure 5. The location of the cross section (A-A') is shown on Figure 4. The estimated glacial drift groundwater contours for each monitoring period are shown on Figures 6 and 7. The average annual fluctuation of the potentiometric surface for the glacial drift during 1993 was approximately 0.9 feet.

2.1.2 Carimona Member of Platteville Formation

Groundwater elevations were also measured in the Carimona Member monitoring wells during May and November of 1993 at the locations shown on Figure 8. A summary of 1993 water level monitoring results is presented in Table 2. The Carimona potentiometric surface elevations for each monitoring period are shown on Figures 9 and 10. The average annual fluctuation of the potentiometric surface for the Carimona Member in 1993 was approximately 1.9 feet.

2.1.3 Magnolia Member of Platteville Formation

The potentiometric surface elevations were measured in the Magnolia Member monitoring wells during May and November of 1993 at the locations previously shown on Figure 11. A summary of 1993 water level monitoring results is presented in Table 3. The Magnolia potentiometric surface elevations for each monitoring period are shown on Figures 12 and 13. The average annual fluctuation of the potentiometric surface for the Magnolia during 1993 was 1.6 feet.

2.1.4 St. Peter Sandstone

The potentiometric surface elevations were measured in the St. Peter Sandstone monitoring wells during May and November of 1993 at the locations shown on Figure 14. A summary of 1993 water level monitoring results is presented in Table 4. The St. Peter potentiometric surface elevations for each monitoring period are shown on Figures 15 and 16. The average annual fluctuation of the potentiometric surface for the St. Peter Sandstone during 1993 was approximately 0.7 feet.

2.2 Water Quality Monitoring

The 1993 monitoring program involved the collection of 63 water quality samples: from monitoring wells screened in the glacial drift aquifer; wells screened in the Carimona and open to the Magnolia Members of the Platteville Formation; wells screened in the St. Peter Sandstone; and one well open to the Prairie du Chien/Jordan. Monitoring activities were carried out in accordance with the 1993 Monitoring Plan.

The results from 1993 water quality monitoring are discussed in the following section and in Section 5.0. Historical water quality data for glacial drift wells, Carimona Member wells, Magnolia Member wells, St. Peter Sandstone wells, Prairie du Chien/Jordan well, pump-out wells, and the groundwater treatment system influent and effluent are presented in Appendix B. (Note: The 1993 water quality monitoring results are considered to be valid as discussed in Section 3.0 and Appendix A of this report.)

2.2.1 Glacial Drift

Groundwater samples were collected from nine glacial drift monitoring wells during May of 1993 and from five glacial drift monitoring wells during November 1993. Samples collected during May 1993 were analyzed for the parameters listed in Table 5. Samples collected during November 1993 were analyzed for TCE. The results from the laboratory analyses are presented in Table 6. The reported concentrations of TCE and the sum of volatile organic compounds (VOCs) are also shown on Figures 17 through 19. The 1985 through 1993 TCE concentrations for glacial drift Wells Q, X, 1, B, V, 3, S, and T are shown on Figure 20.

2.2.2 Carimona Member of Platteville Formation

Groundwater samples were collected from eleven monitoring wells open to the Carimona Member of the Platteville Formation during May 1993, from Carimona Pump-Out Well 108 in June of 1993, and from four Carimona Member monitoring wells and Pump-Out Well 108 during November 1993. The samples collected during May and June 1993 were analyzed for the parameters listed in Table 5. The samples collected during November 1993 were analyzed for TCE. The results from the laboratory analyses are presented in Table 7. The concentration of TCE and the sum of VOCs are shown on Figures 21 through 23. The 1985 through 1993 TCE concentrations for Carimona Wells BB, 108, 13, 10, 11, and WW are shown on Figure 24.

2.2.3 Magnolia Member of Platteville Formation

Groundwater samples were collected from five monitoring wells open to the Magnolia Member of the Platteville Formation during May 1993, and from four Magnolia Member monitoring wells during November 1993. The samples collected during May 1993 were analyzed for the parameters listed in Table 5. The samples collected during November were analyzed for TCE. The results from the laboratory analyses are presented in Table 8. The concentration of TCE and the sum of VOCs are shown on Figures 25 through 27. The 1985 through 1993 TCE concentrations for Magnolia Member Wells ZZ, OO, VV, QQ, and TT are shown on Figure 28.

2.2.4 St. Peter Sandstone

Groundwater samples were collected from four monitoring wells screened in the St. Peter Sandstone during May 1993 and one St. Peter Sandstone monitoring well in November 1993. Samples collected during May were analyzed for the parameters listed in Table 5. Samples collected during November were analyzed for TCE. The results from the laboratory analyses are presented in Table 9. The concentration of TCE and the sum of VOCs are shown on Figures 29 through 31. The 1985 through 1993 TCE concentrations for St. Peter Sandstone Wells 200, 201, 202, and 203 are shown on Figure 32.

2.2.5 Prairie du Chien/Jordan

Groundwater samples were collected from the Henkel well during May and November of 1993. The samples were analyzed for the parameters listed in Table 5. The results from the laboratory analyses are presented in Table 10.

2.2.6 Downgradient Groundwater Pump-Out System

Flow weighted composite groundwater samples were collected from the downgradient pump-out well system discharge during March, May, August, and November of 1993 (1st, 2nd, 3rd, and 4th quarters). The samples collected during May and November of 1993 were analyzed for the parameters listed in Table 11. The samples collected during March and August of 1993 were analyzed for the parameters listed in Table 5. The results from the laboratory analysis are presented in Table 12. The 1985 through 1993 TCE concentrations for the downgradient groundwater pump-out system discharge is shown on Figure 33.

2.2.7 Site Groundwater Treatment & Groundwater Pump-Out System

Groundwater treatment system influent and effluent samples were collected quarterly in 1993 (during March, May, August, and November). Influent to the treatment system is composed of groundwater pumped from Wells 109 and 110. The samples collected in March and August were analyzed for parameters listed in Table 5. The samples collected in May and November were analyzed for the parameters listed in Table 11. The sample collected from the groundwater treatment system influent in May was also analyzed for priority pollutant volatile organics. The results from the laboratory analyses are presented in Tables 13 and 14. The 1985 through 1993 TCE concentrations for the groundwater treatment system influent and effluent are shown on Figure 33.

Magnolia groundwater pump-out system samples were collected quarterly in 1993 (during March, May, August and November). Effluent from the wells is discharged directly to the storm sewer. Flow weighted composite samples were collected from the effluent of Wells MG1 and MG2. The samples collected in March and August were analyzed for the parameters listed in Table 5. The samples collected in May and November were analyzed for the parameters listed in Table 11. The results from the laboratory analysis are presented in Table 15.

3.0 QUALITY ASSURANCE PROCEDURES

Routine quality assurance procedures were followed during collection and analysis of the 1993 water quality samples. Quality assurance procedures involved both internal and external review procedures. The results from the quality review are presented in Appendix A. The results from the quality review indicate the 1993 data is considered valid.

4.0 REMEDIAL ACTION OPERATIONS

The following sections summarize the site construction remedial action operation and maintenance activities conducted at the East Hennepin Avenue site during 1993. Remedial actions during 1993 consisted of the operation of the groundwater pump-out and treatment systems.

4.1 Existing Groundwater Pump-Out Systems

The East Hennepin Avenue site groundwater pump-out systems consist of the site glacial drift pump-out system (Wells 109 and 110) (Figure 4), the site Platteville pump-out system (Wells MG1 and MG2) (Figure 2) and the downgradient glacial drift pump-out system (Wells 111, 112, and 113) (Figure 4). The function of Carimona pump-out well (Well 108) was replaced in 1993 by Wells MG1 and MG2. The performance of each individual pump-out system is discussed in Sections 4.1.1 through 4.1.4. The average monthly pumping rate for each of the pump-out wells is presented in Table 16.

4.1.1 Site Glacial Drift

The site glacial drift pump-out well system (Wells 109 and 110) is designed to contain and remove groundwater with a concentration of trichloroethene (TCE) exceeding 270 $\mu g/L$ from the glacial drift aquifer. The combined average pumping rate for the site glacial drift pump-out well system during 1993 was 93 gallons per minute. The average monthly pumping rates for the individual pump-out wells ranged from 18 to 89 gallons per minute. A total volume of approximately 46 million gallons of groundwater was removed from the glacial drift aquifer by the site glacial drift pump-out system. The site glacial drift pump-out system operated at a combined yearly average operating time of 95 percent during 1993.

Groundwater removed by the site glacial drift pump-out system during 1993 was treated by air stripping. The effluent from the air stripper is discharged to the Minneapolis storm sewer network. The site glacial drift pump-out system began operation on November 1, 1985.

4.1.2 Carimona Member of the Platteville Formation

Carimona Pump-out Well 108 was not operated during 1993. Magnolia Wells MG1 and MG2 serve to extract groundwater from the Carimona Member.

4.1.3 Magnolia Member of the Platteville Formation

The Magnolia pump-out system (Wells MG1 and MG2) is designed to contain and remove groundwater with a concentration of TCE exceeding 27 μg/L from both the Magnolia and Carimona Members of the Platteville Formation. Wells MG1 and MG2 operated at a combined average of 204 gallons per minute. A total volume of approximately 103 million gallons was removed from the Carimona and Magnolia Members by Wells MG1 and MG2 during the 1993. The site Magnolia pump-out system operated at a combined yearly average running time of 97 percent during 1993.

4.1.4 Downgradient Glacial Drift

The downgradient glacial drift pump-out system (Wells 111, 112, and 113) is designed to contain and remove groundwater with a concentration of TCE exceeding 270 μg/L.

The downgradient glacial drift pump-out well system operated at a combined annual average rate of 295 gallons per minute. The average monthly pumping rates for the individual downgradient pump-out wells ranged from 88 to 123 gallons per minute. A total volume of approximately 155 million gallons of groundwater was removed from the glacial drift aquifer by the downgradient glacial drift pump-out system during 1993. The downgradient pump-out system operated at a combined yearly average running time of nearly 100 percent.

Groundwater removed by the downgradient pump-out well system is discharged to the Minneapolis storm sewer network. The downgradient pump-out system began operation on December 5, 1985.

4.2 Maintenance and Downtime

The site and downgradient pump-out wells were operated continuously at the maximum sustainable yield of the pumps or aquifer during 1993, with the exception of shut downs caused by electrical or mechanical failures, and the need for well maintenance.

Maintenance of Wells 109 and 110 during 1993 included repair of the flow meters in Wells 109 and 110. Well 109 was shut down for two days in July for cleaning of the pump, meter, and piping. Well 109 was also shut down for two days in August while the well was redeveloped to maintain yield. Both wells were also off-line from January 29 to February 5 while the stripper packing was removed and replaced. Well 110 was down for ten days in January to replace piping and repair the pump. Wells 109 and 110 were both shut down for two days in March due to a pressure switch failure in the stripper tower.

No significant maintenance activities were performed on the downgradient pump-out wells in 1993.

Magnolia Member pump-out Wells MG1 and MG2 were also off-line during the changeout of stripper packing material. They were also both shut down for a day in May when upgrades were made to the control systems. The pump motor in Well MG2 malfunctioned in April. The well was out of service for 18 days.

Operation downtime occurring during 1993 for the glacial drift and Magnolia Member pump-out wells is summarized in Table 17.

4.3 Groundwater Treatment System

The groundwater treatment system consists of a stripper tower located at the former disposal site. The tower is designed to remove 99 percent of volatile organic compounds from influent groundwater at a discharge rate of 150 gpm. The groundwater treatment system is required to treat influent groundwater to an annual average effluent concentration of less than 50 $\mu g/L$ trichloroethene (TCE), and to a daily maximum concentration of less than 100 $\mu g/L$ TCE. The treatment system is also required to achieve a 98 percent removal efficiency as an annual average and a 95 percent daily removal efficiency based on the ratio of total VOC concentration in the system influent versus effluent.

During 1993 the tower received influent from site glacial drift pump-out Wells 109 and 110. The stripper tower began operation on November 11, 1985.

5.0 DISCUSSION OF RESULTS

This section discusses the water quality data results for samples collected from glacial drift, Carimona Member, Magnolia Member, St. Peter Sandstone, and Prairie du Chien/Jordan monitoring wells. Also discussed are the water quality results for groundwater pump-out system wells, and the groundwater treatment system. Historical water quality data for each location is provided in Appendix B.

A graphical representation of the historical water quality data is also provided on Figures 20, 24, 28, 32, and 33.

5.1 Site Glacial Drift

The results from the analysis of groundwater samples collected from the glacial drift during 1993 indicate the TCE and total VOC concentrations ranged from less than the laboratory reporting limit (Wells Q, T, X and 1) to 740 µg/L at Well 3 (Table 6).

The results from the analysis of groundwater samples collected from the glacial drift Wells B, Q, W, U, and X indicate TCE concentrations have decreased since the start-up of the site glacial drift pump-out system in 1985. The results from the analysis of groundwater samples collected from Wells S, V, T, 1, and 3 during 1993 indicate TCE concentrations are similar to historical water quality data collected from 1985 to 1992.

The groundwater elevation data indicate the direction of groundwater flow in the glacial drift is to the southwest. The data also indicate that 1993 groundwater elevations are similar to historical water elevation data collected from 1985 to 1992. Water level measurements collected during 1985 and 1986, following start-up of the groundwater containment system, demonstrated the effectiveness of the site and downgradient pump-out systems in containment of the glacial drift groundwater in areas where TCE concentrations exceeded 270 µg/L. Glacial drift groundwater elevation data collected during 1993 indicate the containment zone established during 1985 and 1986 has been maintained.

5.2 Carimona Member of Platteville Formation

The results from the analysis of groundwater samples collected from the Carimona Member during 1993 indicate the TCE concentrations ranged from less than the laboratory reporting limit (Well 12) to 940 μg/L at Well BB (Table 7). The total VOCs concentration ranged from not detected (Well 12) to 1,100 μg/L (Well BB).

The results from the analysis of groundwater samples collected from Carimona Member Wells 8, 10, and WW indicate TCE concentrations have declined since the start-up of the Carimona Member pump-out system in 1985. The results from the analysis of groundwater samples collected from Wells BB, RR, SS, UU, and 9 during 1993 indicate TCE concentrations are similar to historical water quality data collected from 1985 to 1992.

The results from the analysis of groundwater samples collected from Wells 11 and 13 during 1985 through 1993 show considerable variability. The TCE concentration of groundwater samples collected from Well 11 range from below the laboratory detection limit (May 1990) to 520 μg/L (December 1985). The TCE concentration of groundwater samples collected from Well 13 range from less than the laboratory reporting limit (April 1991) to 140 μg/L (April 1987).

Carimona Member Well 13 and Magnolia Member Well ZZ are part of a well nest located at the intersection of 21st Avenue Southeast and Fairmont. The vertical gradient in this vicinity is upwards from the Magnolia Member to the Carimona Member of the Platteville Formation. The groundwater quality in the vicinity of Carimona Member Well 13 may be adversely impacted by leakage of Magnolia Member groundwater to the Carimona. The concentration of TCE in the samples of groundwater collected from Magnolia Member Well ZZ are consistently higher than the concentration of TCE in samples collected from Carimona Member Well 13.

One year after shutting down Well 108 and the start-up of Magnolia Pump-out Wells MG1 and MG2, water levels in the Carimona monitoring wells were generally comparable to those measured historically. The potentiometric data (Figures 9 and 10) indicate that water levels in the Carimona are relatively uniform. Water levels in Wells 12 and SS were lower due to relatively high leakage rates into the Magnolia Member in the vicinity of these wells.

5.3 Magnolia Member of Platteville Formation

The results from the analysis of groundwater samples collected from Magnolia Member wells during 1993 indicate the TCE concentrations ranged from 0.7 μg/L (Well TT) to 190 μg/L (Well VV). These same wells contained total VOC concentrations of 1.8 μg/L and 230 μg/L, respectively. Well ZZ is located upgradient of the former disposal area, and contains a relatively large TCE concentration (73 μg/L).

The results from the analysis of groundwater samples collected from the Magnolia Member monitoring wells during 1993 indicate TCE concentrations have decreased in Well TT since the Magnolia pump-out system was implemented. TCE concentrations in the other Magnolia wells are similar to historical water quality data compiled from 1985 to 1992.

The potentiometric surface elevation data indicate the direction of groundwater flow in the Magnolia Member was to the northwest during 1993. The data also indicate that 1993 groundwater elevations are similar to historical water elevation data collected from 1985 to 1992.

5.4 St. Peter Sandstone

The results from the analysis of groundwater samples collected from St. Peter Wells 201, 202, and 203 during 1993 indicate TCE concentrations were either trace or not detected. The average concentration of TCE detected in samples collected from Well 200 during 1993 was approximately 54 μg/L, as previously shown in Table 9. The results from the analysis of groundwater samples collected from Wells 200, 201, 202, and 203 during 1993 indicate TCE concentrations are similar to historical water quality data compiled from 1985 to 1992.

The 1993 potentiometric surface elevation data indicate the general direction of groundwater flow in the St. Peter Sandstone is to the southwest.

The 1993 data is consistent with the potentiometric surface elevation data collected during prior monitoring years.

5.5 Prairie du Chien/Jordan

The results from the analysis of groundwater samples collected from the Henkel well during 1993 indicate the TCE concentrations ranged from 16 to 36 μg/L, as previously shown in Table 10. The VOC concentrations ranged from 17 to 37 μg/L. The results from the analysis of groundwater samples collected from the Henkel well during 1993 indicate TCE concentrations are within the range of historical water quality data compiled from 1985 to 1992.

5.6 Downgradient Pump-Out System

The average concentration of TCE reported for samples collected from the downgradient pump-out system discharge was 76 μg/L, and the average total concentration of VOCs was 100 μg/L, as previously shown in Table 12. The highest concentration of TCE reported during 1993 was 130 μg/L. The highest concentration of total VOCs reported was 140 μg/L. The results from the analysis of discharge samples collected during 1993 indicate the TCE concentrations are similar to historical water quality data compiled from 1985 to 1992.

The 1993 water quality data also indicate the downgradient pump-out system is effective in containing glacial drift groundwater with a concentration of TCE exceeding 270 μg/L. This is evidenced by the water quality of the two monitoring wells located downgradient of the downgradient glacial drift pump-out system. The 1993 data for Wells V and W indicate the TCE concentrations ranged from 2.9 to 100 μg/L (Table 6).

5.7 Site Groundwater Pump-Out Systems

The results from the analysis of samples collected quarterly from the site glacial drift pump-out system indicate the average influent concentration of TCE was 470 μg/L and the average influent concentration of VOCs was 570 μg/L (Table 13). The highest concentration of TCE reported in site pump-out system influent samples during 1993 was 630 μg/L. The maximum total concentration of VOCs reported was 810 μg/L, as shown in Table 14. The results of influent samples collected during 1993 indicate the concentration of TCE has decreased since start-up of the pump-out system in 1985.

The routine volatile organic data (Table 13) and the volatile fraction priority pollutant data (Table 14) indicate TCE remains the primary volatile organic compound present in the groundwater at the East Hennepin Avenue site. TCE comprises approximately 78 percent of the contaminant matrix based on the 1993 volatile fraction priority pollutant data. The 1993 data also indicate the presence of ten other VOCs including: 1,1-dichloroethane, 1,2-dichloroethylene, chloroform, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, benzene, toluene, ethyl benzene, and xylenes. Methylene chloride and acetone were also detected, but are potentially false positive values based on the compounds being detected in the method blank.

The results from the analysis of samples collected quarterly from the Platteville pump-out system indicate the average TCE concentration was 29 μg/L and the average concentration of total VOCs was 30 μg/L (Table 15).

Groundwater modeling contained in Appendix D indicates that pumping rates of 95 gpm for both Wells MG1 and MG2 will effectively capture groundwater in both the Carimona and Magnolia Members. Average annual pumping rates were above 100 gpm for both wells. Monthly pumping rates for both wells were always greater than or equal to 95 gpm (Table 16).

Four of the Carimona Member wells are nested with Magnolia Member wells, Well WW with Well VV, Well SS with Well TT, Well RR with Well OO, and Well 13 with Well ZZ. In 1993, average downward gradients in nests WW/VV, SS/TT, and RR/OO were 6.99 feet, 6.63 feet, and 8.19 feet, respectively.

These gradients, coupled with pumping rate data from both wells, affirm that Pump-out Wells MG1 and MG2 are effectively capturing groundwater in the Magnolia Member as well as the Carimona Member.

A conservative pump-out system capture zone was determined for the pump-out systems at this site. The capture zone was evaluated to identify which monitoring wells could be removed from the monitoring program and to verify the adequacy of the operating plan. The complete discussion of modeling results and the resultant implications are presented in Appendix D.

5.8 Site Groundwater Treatment System

The results from the analysis of samples collected from the treatment system effluent indicate the average TCE concentration was <0.50 μg/L, and the average total VOC concentration was less than the detection limit. No TCE or total VOCs were detected in the effluent in 1993. The treatment system removal efficiency was nearly 100 percent for all four quarters of 1993.

6.0 SUMMARY AND CONCLUSIONS

6.1 Glacial Drift

Water quality and water level data indicate continued containment of groundwater with a concentration of TCE exceeding 270 μg/L in the glacial drift aquifer by the site glacial drift and downgradient glacial drift pump-out systems.

6.2 Carimona Member

The Carimona Member acts as a leaky confining layer above the Magnolia Member. A variable hydraulic connection exists between the Carimona Member and Magnolia Member. The Magnolia Member Pump-out Wells have a greater influence on the vertical gradient from the Carimona Member to the Magnolia Member than did Carimona Pump-out Well 108. The increased hydraulic gradient causes increased leakage from the Carimona Member into the Magnolia Member. Due to the effectiveness of Magnolia Member Pump-out Wells MG1 and MG2, pump-out Well 108 was not operated during 1993.

6.3 Magnolia Member

Magnolia Member water quality and water level data collected from the monitoring network suggests that Pump-out Wells MG1 and MG2 are effectively capturing groundwater in the Platteville formation including the Magnolia Member. Historically, the highest TCE concentrations are consistently found in samples from Magnolia Member wells located upgradient of the site (particularly Well ZZ).

6.4 St. Peter Sandstone

Water quality data collected from the St. Peter wells indicate the continued presence of VOCs in the St. Peter Sandstone aquifer at concentrations similar to historical water quality data.

6.5 Prairie du Chien/Jordan

Water quality data collected from the Henkel well indicate the continued presence of VOCs in the Prairie due Chien/Jordan aquifer at concentrations similar to historical water quality data.

7.0 RECOMMENDATIONS

1. Continued operation of the site pump-out and groundwater treatment systems, and the downgradient glacial drift pump-out systems in accordance with the 1985 Consent Order; the 1985 Groundwater Pump-Out System Plan; the Department of Natural Resources Water Appropriation Permits; and, the 1994-1999 Monitoring Plan (Appendix C).

2. Ongoing inspection and maintenance of the groundwater pump-out and treatment systems.

3. Removal of stripper tower packing material as required.

4. Continue submittal of data on quarterly basis.

5. Monitoring of groundwater elevations and groundwater quality in accordance with the Proposed 1994-1999 Monitoring Plan (Appendix C).

Tables

TABLE 1

1993 GROUNDWATER ELEVATIONS
GLACIAL DRIFT WELLS

(elevations in feet/MSL)

DATE	1	3	109 (1)	110 (1)	111 (1)
05/18/93	842.00	833.85	827.24	829.56	818.46
11/22/93	842.17	834.07	828.06	830.81	819.26

DATE	112 (1)	113 (1)	B	Q	S
05/18/93	807.05	818.74	843.47	828.18	827.04
11/22/93	810.43	819.83	843.64	828.42	828.07

DATE	T	U	V	W	X
05/18/93	832.56	836.22	816.13	816.29	822.55
11/22/93	833.74	836.42	817.17	817.23	823.81

---

(1) Pump-out well.
-- Not measured.

2,.021
12/23/93

TABLE 2

1993 GROUNDWATER ELEVATIONS
CARIMONA MEMBER WELLS

(elevations in feet/MSL)

DATE	8	9	10	11	12
05/18/93	827.37	827.38	827.58	827.39	826.95
11/22/93	829.26	829.34	829.45	829.56	828.36

DATE	13	108 (1)	BB	RR	SS
05/18/93	826.72	827.46	827.16	827.48	822.62
11/22/93	828.89	829.53	829.29	829.63	823.68

DATE	UU	WW
05/18/93	827.40	827.04
11/22/93	829.50	829.50

(1) Former pump-out well.

2,.020
12/23/93

TABLE 3

1993 GROUNDWATER ELEVATIONS
MAGNOLIA MEMBER WELLS

(elevations in feet/MSL)

DATE	OO	QQ	TT	VV	ZZ
05/18/93	820.42	818.46	815.64	820.33	828.12
11/22/93	820.28	820.31	817.42	822.23	830.26

DATE	MG1 (1)	MG2 (1)
05/18/93	--	--
11/22/93	809.46	810.07

-- Not measured.
(1) Pump-out well.

2,.022
12/23/93

TABLE 4

1993 GROUNDWATER ELEVATIONS
ST. PETER SANDSTONE WELLS

(elevations in feet/MSL)

DATE	200	201	202	203
05/18/93	763.12	778.52	754.94	754.05
11/22/93	764.00	780.11	754.86	753.79

2,.023
12/23/93

TABLE 5

GROUNDWATER MONITORING SYSTEM
1993 WATER QUALITY ANALYTICAL PARAMETERS

Chlorinated Volatile Organic Compounds

1,1-Dichloroethane

1,2-Dichloroethane

1,2-Dichloroethylene, cis

1,2-Dichloroethylene, trans

1,1,2,2-Tetrachloroethane

Tetrachloroethylene

1,1,1-Trichloroethane

Trichloroethene

TABLE 6

1993 WATER QUALITY DATA
GLACIAL DRIFT WELLS

(concentrations in ug/L)

	B	Q	S		T	U	V	
	05/18/93	05/18/93	05/18/93	11/23/93	05/18/93	05/18/93	05/18/93	11/22/93
1,1-Dichloroethane	1.4	<0.50	<0.50	--	<0.50	<0.50	<0.50	--
1,2-Dichloroethylene, cis	5.1	<0.50	11	--	<0.50	<0.50	4.8	--
1,2-Dichloroethylene, trans	<0.50	<0.50	0.5	--	<0.50	<0.50	<0.50	--
1,2-Dichloroethane	<0.50	<0.50	<0.50	--	<0.50	<0.50	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	--	<0.50	<0.50	<0.50	--
Tetrachloroethylene	5.2	<0.50	2.1	--	<0.50	<0.50	<0.50	--
1,1,1-Trichloroethane	1.7	1.0	<0.50	--	<0.50	<0.50	<0.50	--
Trichloroethylene	580	<0.50	390	400	<0.50	0.7	68	100
Sum Volatile Organics	590	1.0	400	400	ND	0.7	73	100

	W		X	1		3	
	05/19/93	11/22/93	05/18/93	05/18/93	11/22/93	05/18/93	11/22/93
1,1-Dichloroethane	<0.50	--	<0.50	<0.50	--	3.8	--
1,2-Dichloroethylene, cis	0.8	--	<0.50	<0.50	--	33	--
1,2-Dichloroethylene, trans	<0.50	--	<0.50	<0.50	--	<0.50	--
1,2-Dichloroethane	<0.50	--	<0.50	<0.50	--	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	<0.50	--	<0.50	--
Tetrachloroethylene	<0.50	--	<0.50	1.0	--	3.7	--
1,1,1-Trichloroethane	<0.50	--	<0.50	<0.50	--	1.5	--
Trichloroethylene	2.9	2.9	<0.50	<0.50	<0.50	470	740
Sum Volatile Organics	3.7	2.9	ND	1.0	ND	510	740

-- Not analyzed.
ND Not detected.

3,.005
01/19/94

TABLE 7

1993 WATER QUALITY DATA
CARIMONA MEMBER WELLS

(concentrations in ug/L)

	BB	RR	SS	UU	WW	8
	05/19/93	05/19/93	05/18/93	05/18/93	05/18/93	05/19/93
1,1-Dichloroethane	5.4	1.3	3.2	<0.50	<0.50	0.6
1,2-Dichloroethylene, cis	95	39	1.2	3.1	27	2.3
1,2-Dichloroethylene, trans	1.1	<0.50	<0.50	<0.50	1.4	<0.50
1,2-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	0.8
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethylene	12	<0.50	<0.50	<0.50	<0.50	0.6
1,1,1-Trichloroethane	3.3	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethylene	940	93	2.5	29	130	92
Sum Volatile Organics	1100	130	6.9	32	160	96

	9		10		11	
	05/19/93	11/23/93	05/19/93	11/23/93	05/18/93	11/23/93
1,1-Dichloroethane	0.5	--	<0.50	--	<0.50	--
1,2-Dichloroethylene, cis	<0.50	--	<0.50	--	4.8	--
1,2-Dichloroethylene, trans	<0.50	--	<0.50	--	<0.50	--
1,2-Dichloroethane	0.6	--	<0.50	--	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	--	<0.50	--
Tetrachloroethylene	<0.50	--	<0.50	--	<0.50	--
1,1,1-Trichloroethane	<0.50	--	<0.50	--	<0.50	--
Trichloroethylene	1.9	0.78	46	43	120	180
Sum Volatile Organics	3.0	0.78	46	43	120	180

	12		13	108	
	05/19/93	11/23/93	05/18/93	06/08/93	11/23/93
1,1-Dichloroethane	<0.50	--	<0.50	3.2	--
1,2-Dichloroethylene, cis	<0.50	--	1.1	88	--
1,2-Dichloroethylene, trans	<0.50	--	<0.50	2.2	--
1,2-Dichloroethane	<0.50	--	<0.50	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	<0.50	--
Tetrachloroethylene	<0.50	--	<0.50	2.9	--
1,1,1-Trichloroethane	<0.50	--	<0.50	0.87	--
Trichloroethylene	<0.50	<0.50	26	640	300
Sum Volatile Organics	ND	ND	27	740	300

-- Not analyzed.
ND Not detected.

3.006
12/21/93

TABLE 8

1993 WATER QUALITY DATA
MAGNOLIA MEMBER WELLS

(concentrations in ug/L)

	OO		QQ	TT	
	05/19/93	11/23/93	05/19/93	05/18/93	11/22/93
1,1-Dichloroethane	<0.50	--	<0.50	<0.50	--
1,2-Dichloroethylene, cis	<0.50	--	3.4	1.2	--
1,2-Dichloroethylene, trans	<0.50	--	<0.50	<0.50	--
1,2-Dichloroethane	<0.50	--	<0.50	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	<0.50	--
Tetrachloroethylene	<0.50	--	<0.50	<0.50	--
1,1,1-Trichloroethane	<0.50	--	<0.50	<0.50	--
Trichloroethylene	11	5.7	13	0.7	1.8
Sum Volatile Organics	11	5.7	16	1.9	1.8

	VV		ZZ	
	05/18/93	11/22/93	05/19/93	11/23/93
1,1-Dichloroethane	1.1	--	<0.50	--
1,2-Dichloroethylene, cis	39	--	1.7	--
1,2-Dichloroethylene, trans	<0.50	--	<0.50	--
1,2-Dichloroethane	<0.50	--	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	--
Tetrachloroethylene	1.4	--	<0.50	--
1,1,1-Trichloroethane	<0.50	--	<0.50	--
Trichloroethylene	190	150	73	70
Sum Volatile Organics	230	150	75	70

-- Not analyzed.

3.007
12/21/93

TABLE 9

1993 WATER QUALITY DATA
ST. PETER SANDSTONE WELLS

(concentrations in ug/L)

	200		201	202	203
	05/19/93	11/23/93	05/19/93	05/19/93	05/19/93
1,1-Dichloroethane	<0.50	--	<0.50	<0.50	<0.50
1,2-Dichloroethylene, cis	11	--	<0.50	<0.50	<0.50
1,2-Dichloroethylene, trans	<0.50	--	<0.50	<0.50	<0.50
1,2-Dichloroethane	<0.50	--	<0.50	<0.50	<0.50
1,1,2,2-Tetrachloroethane	<0.50	--	<0.50	<0.50	<0.50
Tetrachloroethylene	<0.50	--	<0.50	<0.50	<0.50
1,1,1-Trichloroethane	<0.50	--	<0.50	<0.50	<0.50
Trichloroethylene	89	19	<0.50	<0.50	1.4
Sum Volatile Organics	100	19	ND	ND	1.4

ND Not detected.
-- Not analyzed.

3.008
12/21/93

TABLE 10

1993 WATER QUALITY DATA
PRAIRE DU CHIEN/JORDAN WELL

(concentrations in ug/L)

	HENKEL	
	05/19/93	11/23/93
1,1-Dichloroethane	0.52	1.0
1,2-Dichloroethylene, cis	<0.50	<0.50
1,2-Dichloroethylene, trans	<0.50	<0.50
1,2-Dichloroethane	<0.50	<0.50
1,1,2,2-Tetrachloroethane	<0.50	<0.50
Tetrachloroethylene	<0.50	<0.50
1,1,1-Trichloroethane	<0.50	<0.50
Trichloroethylene	16	36
Sum Volatile Organics	17	37

3,.009
12/21/93

TABLE 11

GROUNDWATER PUMP-OUT AND TREATMENT SYSTEM
1993 WATER QUALITY PARAMETERS

Chlorinated Volatile Organic Compounds

1,1-Dichloroethane

1,2-Dichloroethane

1,2-Dichloroethylene, cis

1,2-Dichloroethylene, trans

1,1,2,2-Tetrachloroethane

Tetrachloroethylene

1,1,1-Trichloroethane

Trichloroethene

Non-Chlorinated Volatile Organic Compounds

Benzene

Toluene

Xylenes

TABLE 12

1993 WATER QUALITY DATA
DOWNGRADIENT PUMP-OUT SYSTEM

(concentrations in ug/L)

	DISCHARGE (1)			
	03/02/93	05/19/93	08/23/93	11/23/93
1,1-Dichloroethane	--	<0.50	--	<0.50
1,2-Dichloroethylene, cis	--	5.4	--	3.2
1,2-Dichloroethylene, trans	--	<0.50	--	<0.50
1,2-Dichloroethane	--	<0.50	--	<0.50
1,1,2,2-Tetrachloroethane	--	<0.50	--	<0.50
Tetrachloroethylene	--	0.77	--	0.72
1,1,1-Trichloroethane	--	0.5	--	0.69
Trichloroethylene	130	82	83	78
Benzene	--	<0.50	--	<0.50
Toluene	--	<0.50	--	<0.50
Xylenes	--	<0.50	--	<0.50
Sum Volatile Organics	130	89	83	83

----
(1) Pump-out wells 111, 112, 113.
-- Not analyzed

3,.010
12/21/93

TABLE 13

1993 WATER QUALITY DATA
SITE PUMP-OUT AND TREATMENT SYSTEMS

(concentrations in ug/L)

	INFLUENT (1)			
	03/08/93	05/19/93	08/23/93	11/23/93
1,1-Dichloroethane	--	1.6	--	2.4
1,2-Dichloroethylene, cis	--	47	--	55
1,2-Dichloroethylene, trans	--	<0.50	--	<0.50
1,2-Dichloroethane	--	<0.50	--	1.1
1,1,2,2-Tetrachloroethane	--	1.9	--	<0.50
Tetrachloroethylene	--	2.7	--	7.3
1,1,1-Trichloroethane	--	1.0	--	3.1
Trichloroethylene	270	450 h	530	630
Benzene	--	6.3	--	14
Toluene	--	23	--	72
Xylenes	--	5.3	--	21
Sum Volatile Organics	270	540	530	810

	EFFLUENT (2)			
	03/08/93	05/19/93	08/23/93	11/23/93
1,1-Dichloroethane	--	<0.50	--	<0.50
1,2-Dichloroethylene, cis	--	<0.50	--	<0.50
1,2-Dichloroethylene, trans	--	<0.50	--	<0.50
1,2-Dichloroethane	--	<0.50	--	<0.50
1,1,2,2-Tetrachloroethane	--	<0.50	--	<0.50
Tetrachloroethylene	--	<0.50	--	<0.50
1,1,1-Trichloroethane	--	<0.50	--	<0.50
Trichloroethylene	<0.50	<0.50	<0.50	<0.50
Benzene	--	<0.50	--	<0.50
Toluene	--	<0.50	--	<0.50
Xylenes	--	<0.50	--	<0.50
Sum Volatile Organics	ND	ND	ND	ND

----
(1) Pump-out wells 109, 110.
(2) Effluent from groundwater treatment system.
h EPA sample extraction or analysis holding time was exceeded.
-- Not analyzed.
ND Not detected.

3.011
12/21/93

TABLE 14

WATER QUALITY DATA
PRIORITY POLLUTANT VOLATILE ORGANIC ANALYSIS
EPA METHOD 624
MAY 19, 1993

(concentrations in ug/L)

	(1) INFLUENT	TRIP BLANK	LAB BLANK	
	05/19/93	05/19/93	05/19/93	05/19/93
Chloromethane	<10	<10	<10	<10
Bromomethane	<10	<10	<10	<10
Vinyl Chloride	<10	<10	<10	<10
Chloroethane	<10	<10	<10	<10
Methylene Chloride	3 bj	9 b	4 j	<5
Acetone	2 bj	2 bj	2 j	<10
Carbondisulfide	<5	<5	<5	<5
Trichlorofluoromethane	<5	<5	<5	<5
1,1-Dichloroethylene	<5	<5	<5	<5
1,1-Dichloroethane	4 j	<5	<5	<5
1,2-Dichloroethylene	74	<5	<5	<5
Chloroform	2 j	<5	<5	<5
1,2-Dichloroethane	<5	<5	<5	<5
Methyl Ethyl Ketone	<10	<10	<10	<10
1,1,1-Trichloroethane	2 j	<5	<5	<5
Carbon Tetrachloride	<5	<5	<5	<5
Vinyl Acetate (Vinyl Ester)	<10	<10	<10	<10
Bromodichloromethane	<5	<5	<5	<5
1,2-Dichloropropane	<5	<5	<5	<5
Cis-1,3-Dichloro-1-propene	<5	<5	<5	<5
Trichloroethylene	520	<5	<5	<5
Chlorodibromomethane	<5	<5	<5	<5
1,1,2-Trichloroethane	<5	<5	<5	<5
Benzene	10	<5	<5	<5
Trans-1,3-Dichloro-1-propene	<5	<5	<5	<5
2-Chloroethylvinyl Ether	<10	<10	<10	<10
Bromoform	<5	<5	<5	<5
2-Hexanone	<10	<10	<10	<10
Methyl Isobutyl Ketone	<10	<10	<10	<10
Tetrachloroethylene	7	<5	<5	<5
1,1,2,2-Tetrachloroethane	1 j	<5	<5	<5
Toluene	30	<5	<5	<5
Chlorobenzene	<5	<5	<5	<5
Ethyl Benzene	2 j	<5	<5	<5
Styrene	<5	<5	<5	<5
Xylenes	10	<5	<5	<5
1,3-Dichlorobenzene, volatiles	<5	<5	<5	<5
1,4-Dichlorobenzene, volatiles	<5	<5	<5	<5
1,2-Dichlorobenzene, volatiles	<5	<5	<5	<5
Sum Volatile Organics	670			

-- Not analyzed.
b Potential false positive value based on blank data validation procedure.
j Reported value is less than the detection limit.
(1) Flow rate weighted composite sample (Pump-out wells 109,110).

3,.012
12/22/93

TABLE 15

1993 WATER QUALITY DATA
MAGNOLIA PUMP-OUT SYSTEM

(concentrations in ug/L)

	MG1	MG2	MG EFFLUENT (1)		
	03/02/93	03/02/93	05/19/93	08/23/93	11/23/93
1,1-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethylene, cis	1.4	1.1	1.2	1.5	1.3
1,2-Dichloroethylene, trans	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethylene	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1-Trichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethylene	47	24	22	33	24
Benzene	--	--	<0.50	--	<0.50
Toluene	--	--	<0.50	--	<0.50
Xylenes	--	--	<0.50	--	<0.50
Sum Volatile Organics	48	25	23	35	25

-- Not analyzed.
(1) Pump-out wells MG1 AND MG2.

3,.013
01/19/94

TABLE 16

PUMP-OUT WELLS

1993 PUMPING RATES

	GLACIAL DRIFT PUMP-OUT WELL AVERAGE PUMPING RATE (GPM)					MAGNOLIA PUMP-OUT WELL AVERAGE PUMPING RATE (GPM)	
	109	110	111	112	113	MG1	MG2
Jan 1993	59	21	93	113	88	105[1]	96
Feb 1993	59	59[1]	93	110	88	105[1]	96
Mar 1993	61	89	94	108	89	103	95
Apr 1993	51	55	95	105	89	106	102
May 1993	49	55	95	103	89	102	103
Jun 1993	36	49[1]	95	105	89	101	103
Jul 1993	18	50	95	114	89	102	102
Aug 1993	30[2]	50[1]	95	116	89	102	104
Sep 1993	33	50[1]	96	123	89	103	104
Oct 1993	35	50	96[1]	122	89	103	104
Nov 1993	28	48	96	111	89	103	104
Dec 1993	28[1]	49	96	105	90	103	104
Annual Avg. Pumping Rate (gpm)	41[3]	52[3]	95[3]	111[3]	89[3]	103[3]	101[3]

[1] Flow meter malfunction, estimated flow rate.

[2] Well down for one day for redevelopment.

[3] Average pumping rate calculated only for period when well was in operation.

TABLE 17

PUMP-OUT WELLS
1993 OPERATION DOWNTIME

	GLACIAL DRIFT PUMP-OUT WELL DOWNTIME (DAYS)					MAGNOLIA PUMP-OUT WELL DOWNTIME (DAYS)	
	109	110	111	112	113	MG1	MG2
Jan 1993	4[1]	14[1,8]	0	0	0	0	0
Feb 1993	3[1]	3[1]	0	0	0	3[1]	3[1]
Mar 1993	2[2]	2[2]	0	0	0	0	0
Apr 1993	0	0	0	0	0	0	18[3]
May 1993	0	0	0	0	0	1[4]	1[4]
Jun 1993	1[5]	1[5]	0	0	0	0	0
Jul 1993	2[6]	0	0	0	0	0	0
Aug 1993	2[7]	2[5]	0	0	0	0	0
Sep 1993	0	0	0	0	0	0	0
Oct 1993	0	0	0	0	0	0	0
Nov 1993	0	0	0	0	0	0	0
Dec 1993	0	0	0	0	0	0	0
Percent (%) Operating Time	96	94	100	100	100	99	94

[1] Well shut down due to stripper maintenance.

[2] Stripper and wells shut down due to pressure switch failure.

[3] Pump inoperable due to broken motor flange.

[4] Control systems were upgraded.

[5] Well not operating full-time due to flow meter repair.

[6] Well was cleaned and inspected.

[7] Well was redeveloped.

[8] Pump repaired and piping replaced.

Figures

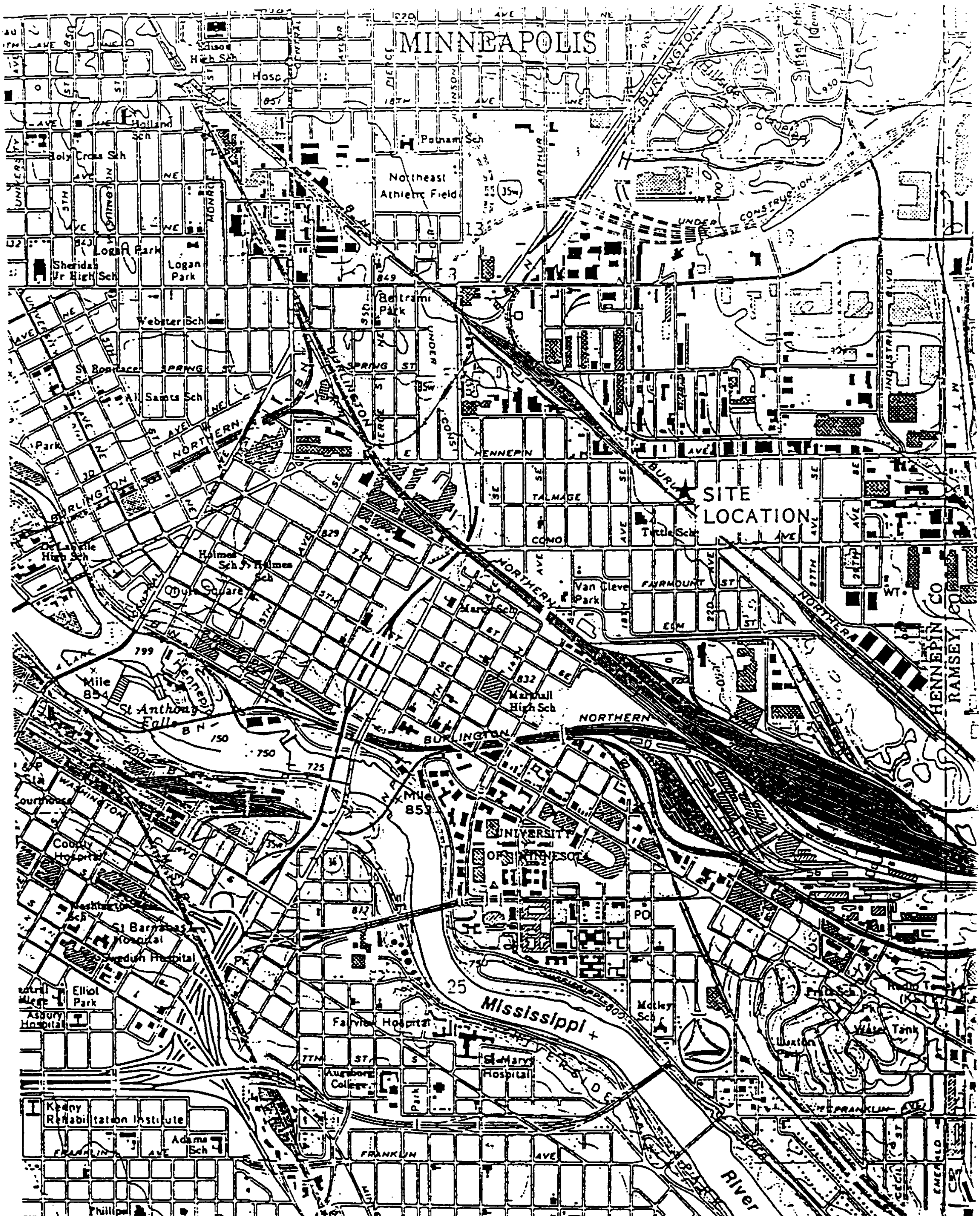


Figure 1

EAST HENNEPIN AVENUE SITE
REGIONAL LOCATION MAP

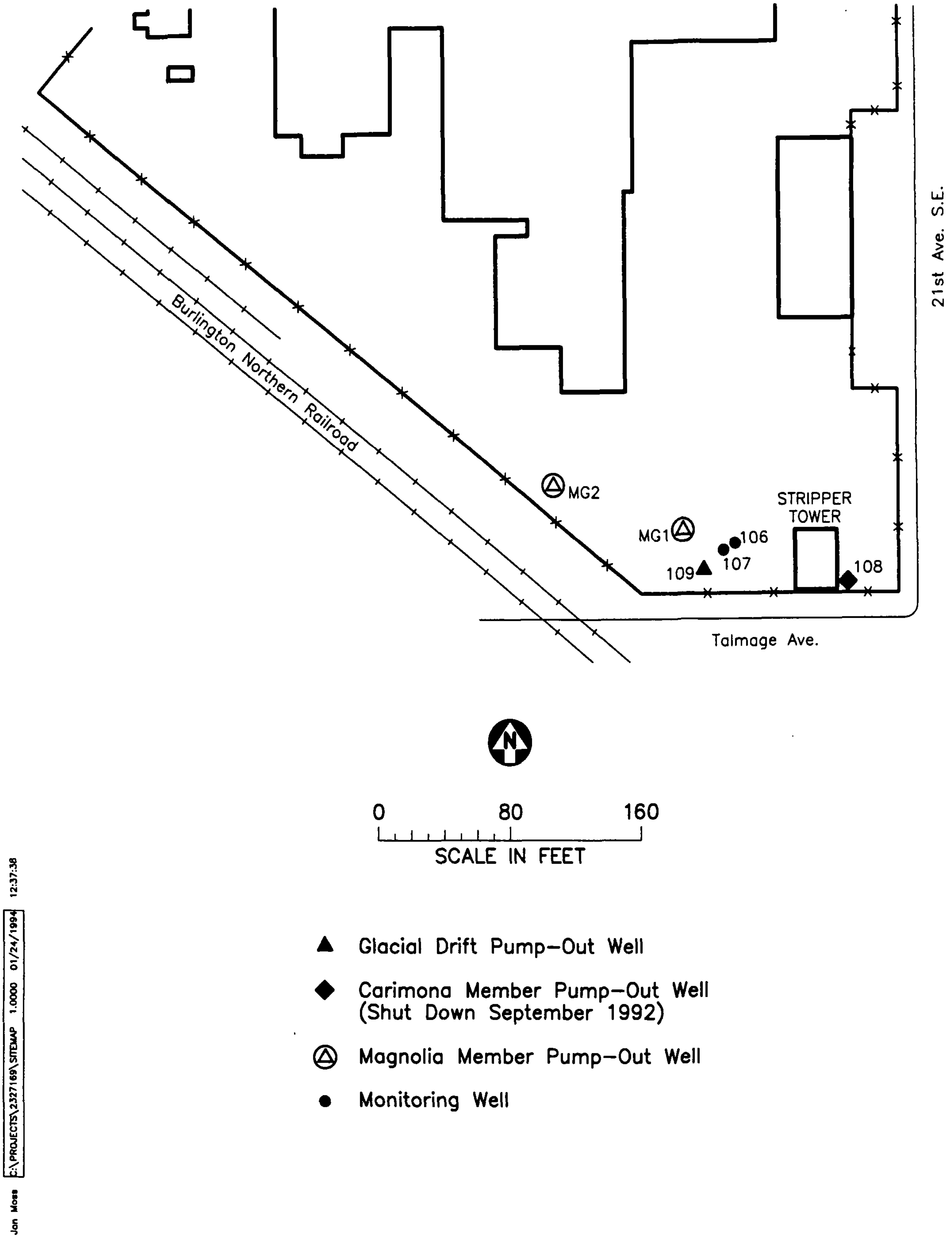
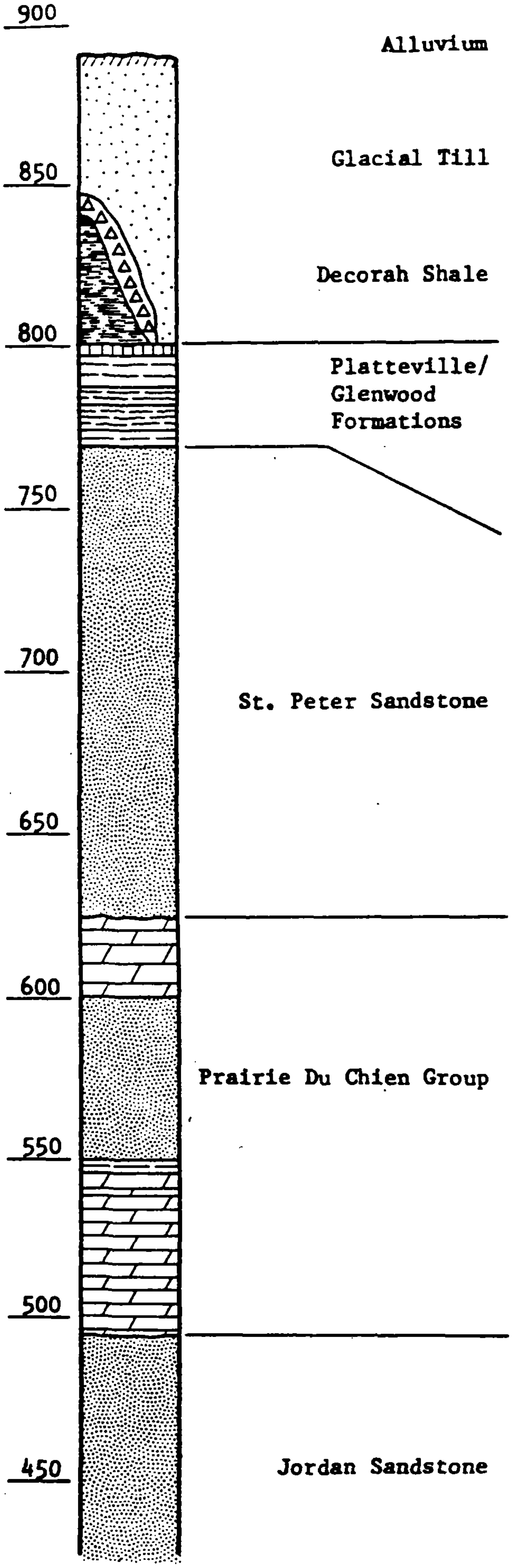


Figure 2

EAST HENNEPIN AVENUE
SITE MAP



Alluvium

Sand, gravelly sand and silty sand, sometimes overlain by bogs and marshes which have been drained and filled. Overlying soil is variable in composition often clayey or silty. Deposits are terrace deposits from Glacial River Warren. Thickness ranges from 23 to 57 feet.

Glacial Till

Gray and red tills associated with Des Moines and Superior lobes. Unsorted material with variable texture containing clay sizes and boulders. Sometimes underlain by thin layer of alluvium. Contains sand lenses. Absent in many places, up to 20' thick.

Decorah Shale

Greenish-gray to olive-gray claystone, fissile, fossiliferous, contains several limestone layers. Patchy in this area. Thicknesses range up to 50'.

Platteville/ Glenwood Formations

Carimona member - micrite, fossiliferous, often fractured and weathered, 3.5-4.5' thick.
Magnolia member - fossiliferous micrite, calcitic shale, with rippled bedding, corroded zones, some fractures. 8.5-9' thick.
Hidden Falls - micrite, shaly, fossiliferous, 6-7' thick.
Mifflin member, thin beds of limestone, interbedded shale 12-13' thick.
Pecatonica member - dolomite, hard, 1-1.5' thick.
Glenwood shale - green shale, sandy at the base, 3-5' thick.

St. Peter Sandstone

Light yellow or white, medium grained, massive appearing sandstone composed of rounded and subrounded grains. Thin beds of green shale are present. Ranges in thickness from 150-170'.

Prairie Du Chien Group

Thickness of entire formation is 120'-150'.
Oneota Dolomite - thin to thick bedded, light brownish gray or buff, fine- to medium-grained dolomite, silt sized dolomite matrix.
New Richmond Sandstone - fine- to medium-grained quartzose sandstone and quartzitic dolomite, minor amounts of shale and pure dolomite.
Willow River Dolomite - thin to thick bedded dolomite, sandy dolomite with some interbedded quartzose sandstone.

Jordan Sandstone

Argillaceous and dolomitic quartz sandstone with pebble-size clasts of dolomitic sandstone and thin beds of dolomite, white or yellow, coarse to medium-grained orthoquartzites to yellow, silty, fine grained quartzose sandstone. 85-100' thick. Underlain by the St. Lawrence Formation which is 120'-200' thick and contains a variety of silty or sandy dolomitic rocks.

Figure 3
GENERALIZED GEOLOGIC COLUMN

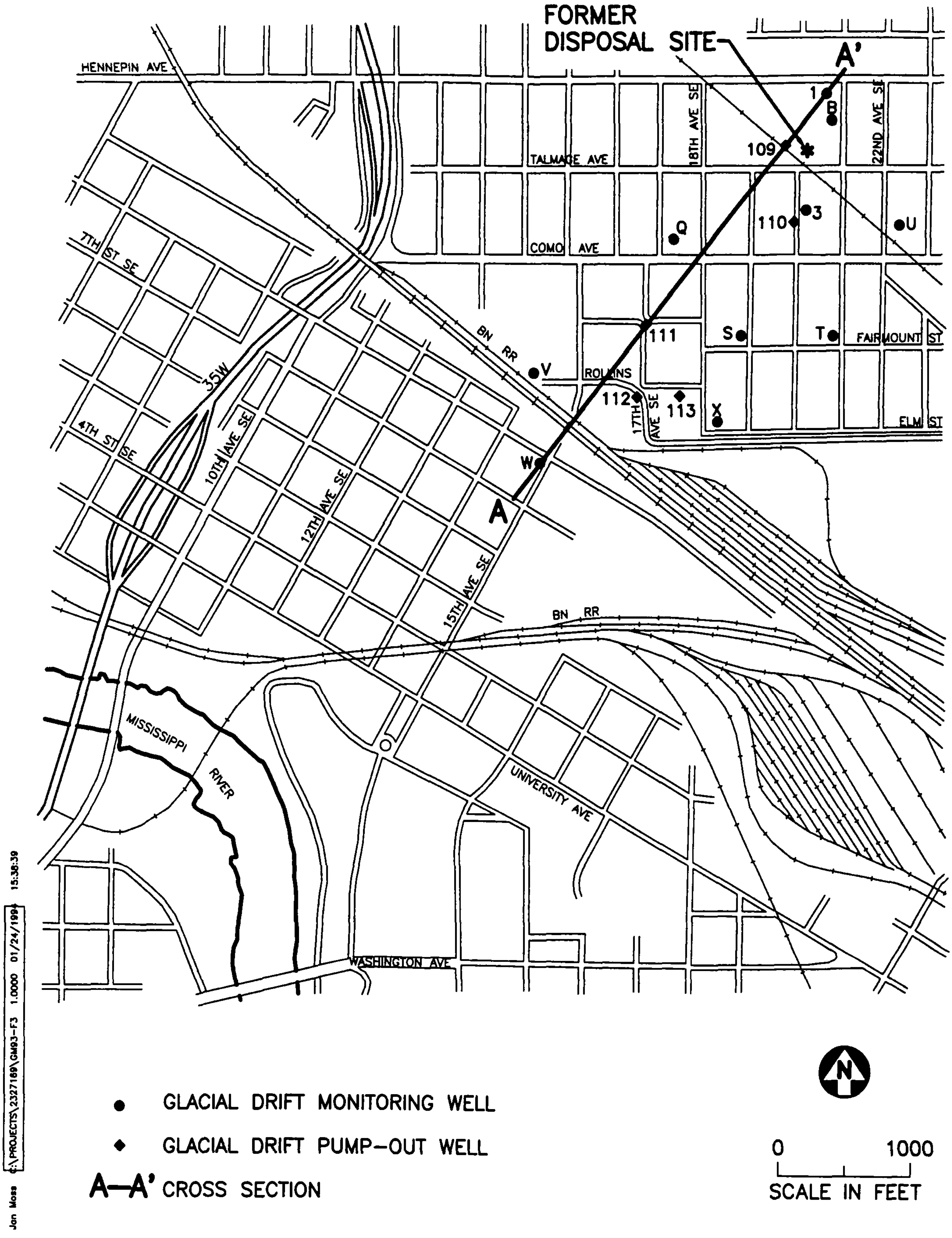


Figure 4
1993 MONITORING LOCATIONS
GLACIAL DRIFT

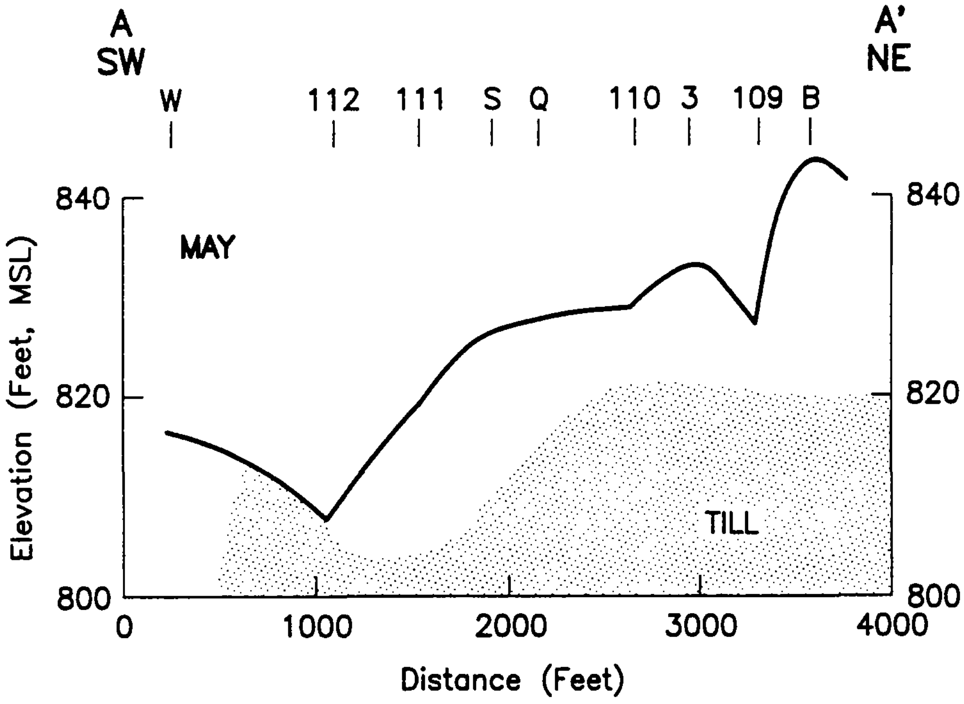
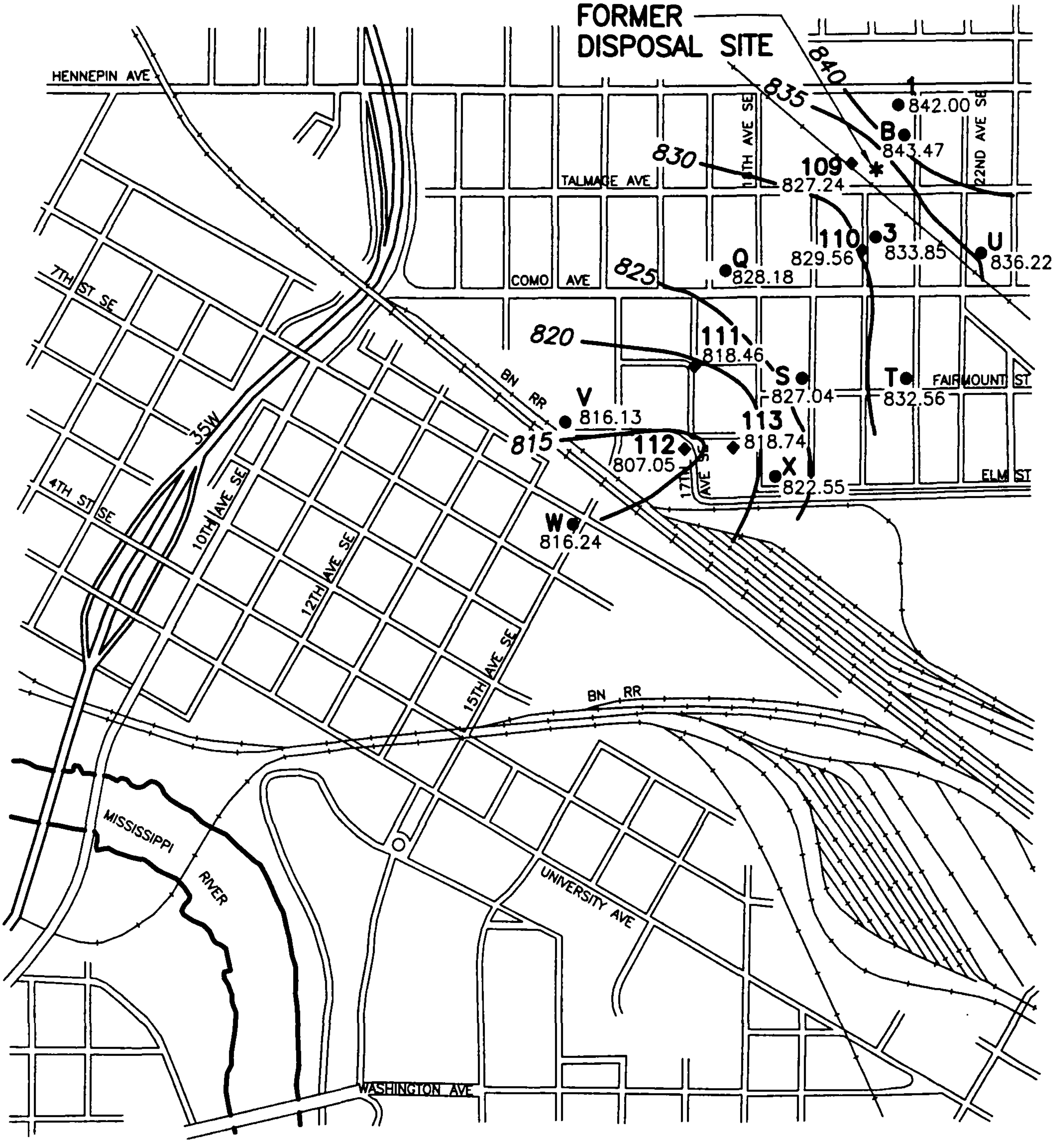


Figure 5

CROSS SECTION A–A'
GLACIAL DRIFT WATER TABLE ELEVATIONS
May, November 1993



● GLACIAL DRIFT MONITORING WELL

◆ SITE AND DOWNGRADIENT GLACIAL DRIFT PUMP-OUT WELL

—828— GLACIAL DRIFT POTENTIOMETRIC SURFACE CONTOUR (MSL)

817.81 GLACIAL DRIFT POTENTIOMETRIC SURFACE ELEVATION (MSL)

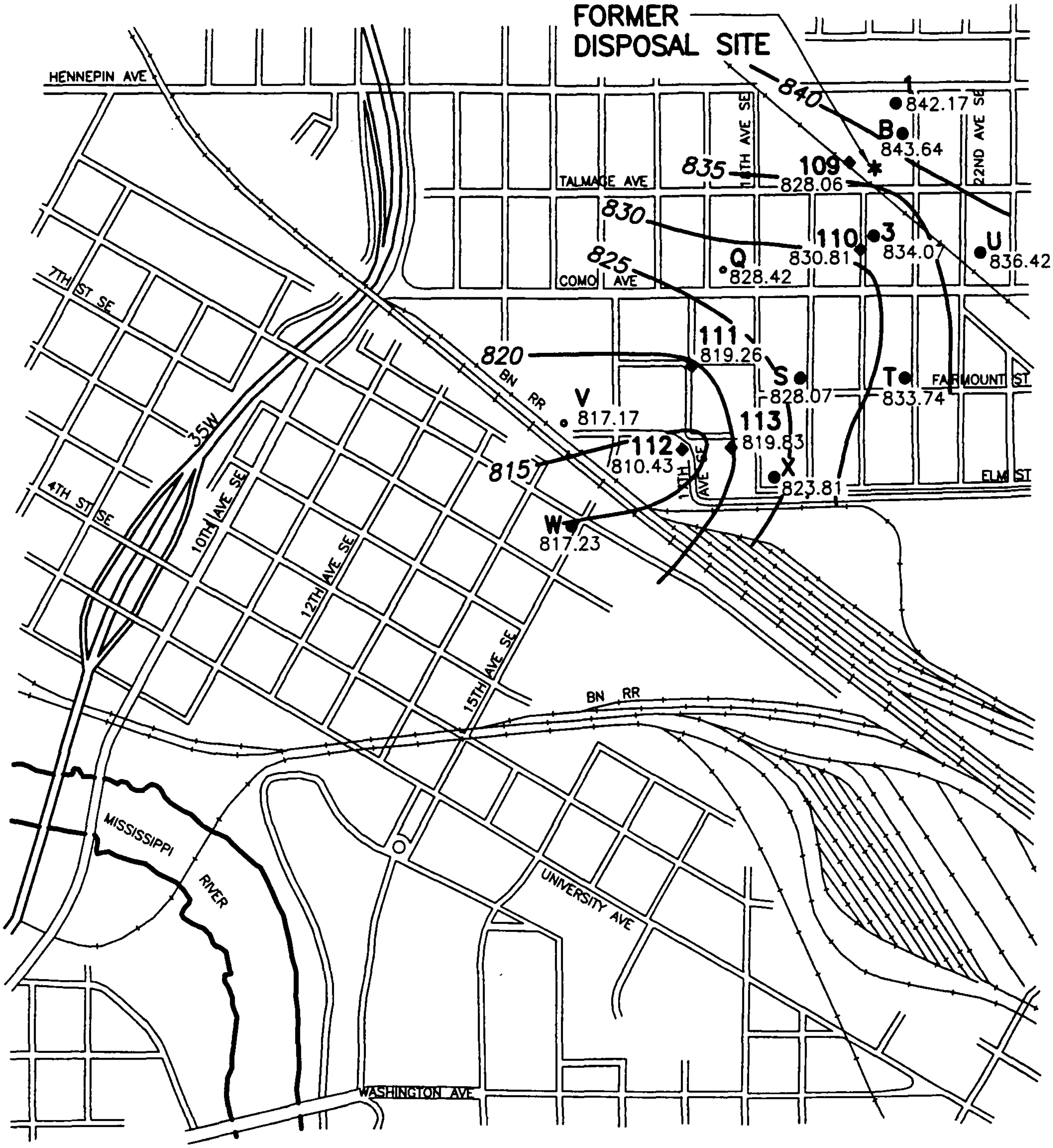
N

0 1000
SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\GWT593 1.00 01/24/1994 12:40:11

Figure 6

GLACIAL DRIFT AQUIFER
WATER TABLE ELEVATIONS
MAY 1993



● GLACIAL DRIFT MONITORING WELL

◆ SITE AND DOWNGRADIENT GLACIAL DRIFT PUMP-OUT WELL

—828— GLACIAL DRIFT POTENTIOMETRIC SURFACE CONTOUR (MSL)

817.23 GLACIAL DRIFT POTENTIOMETRIC SURFACE ELEVATION (MSL)

N

0 1000
SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\GWT1193 1.00 01/24/1994 12:41:03

Figure 7

GLACIAL DRIFT AQUIFER
WATER TABLE ELEVATIONS
NOVEMBER 1993

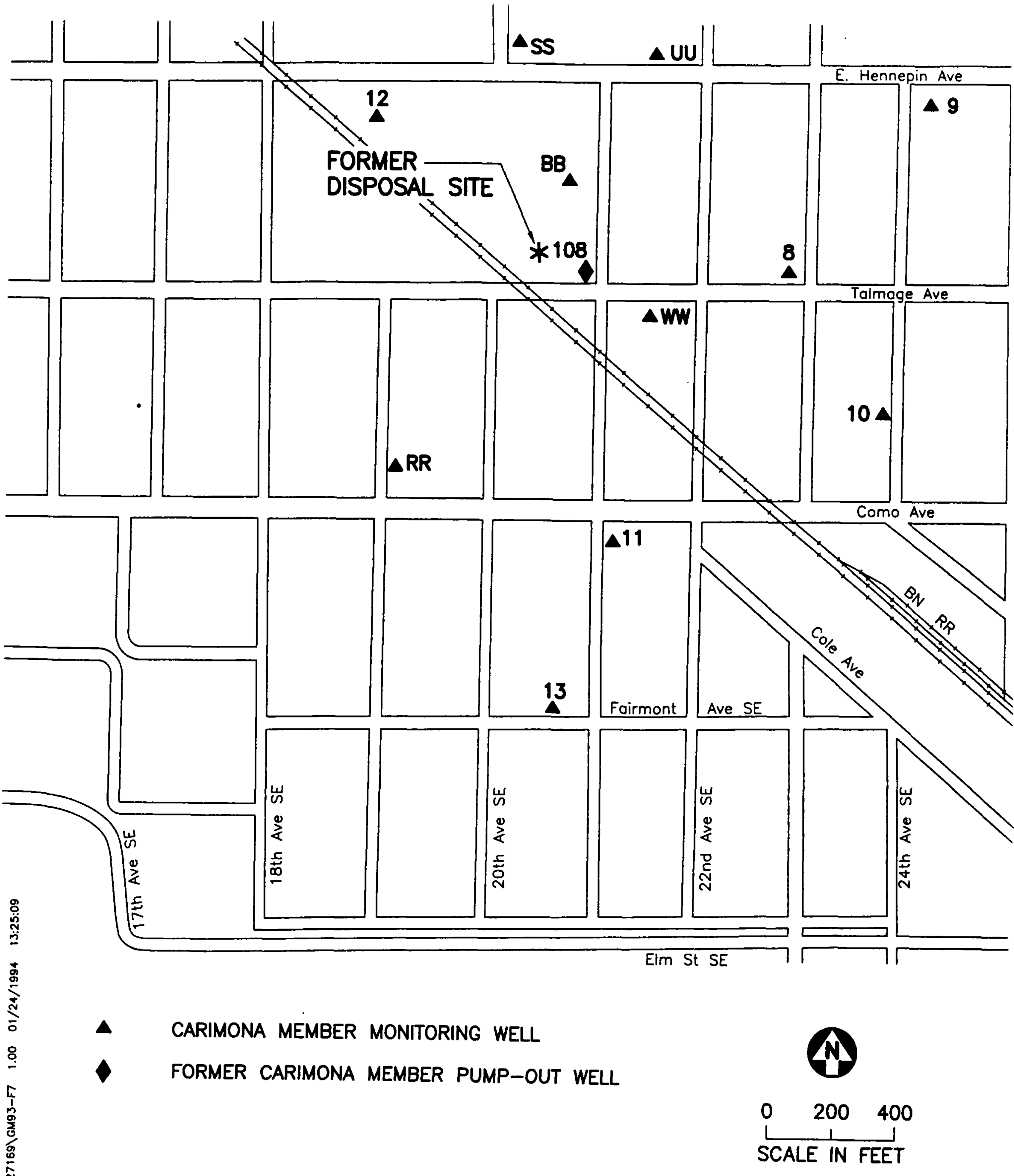
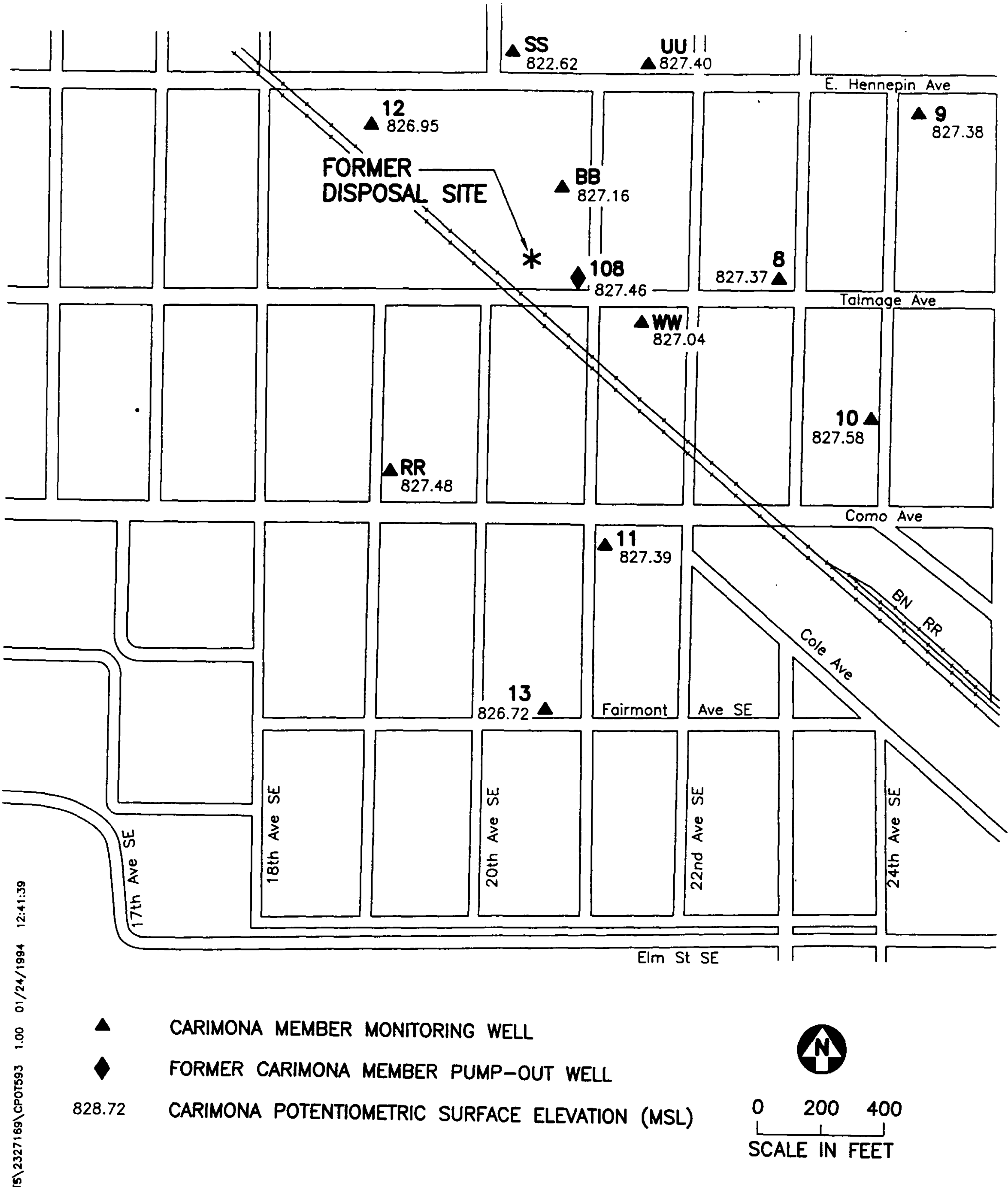


Figure 8

1993 MONITORING LOCATIONS
CARIMONA MEMBER

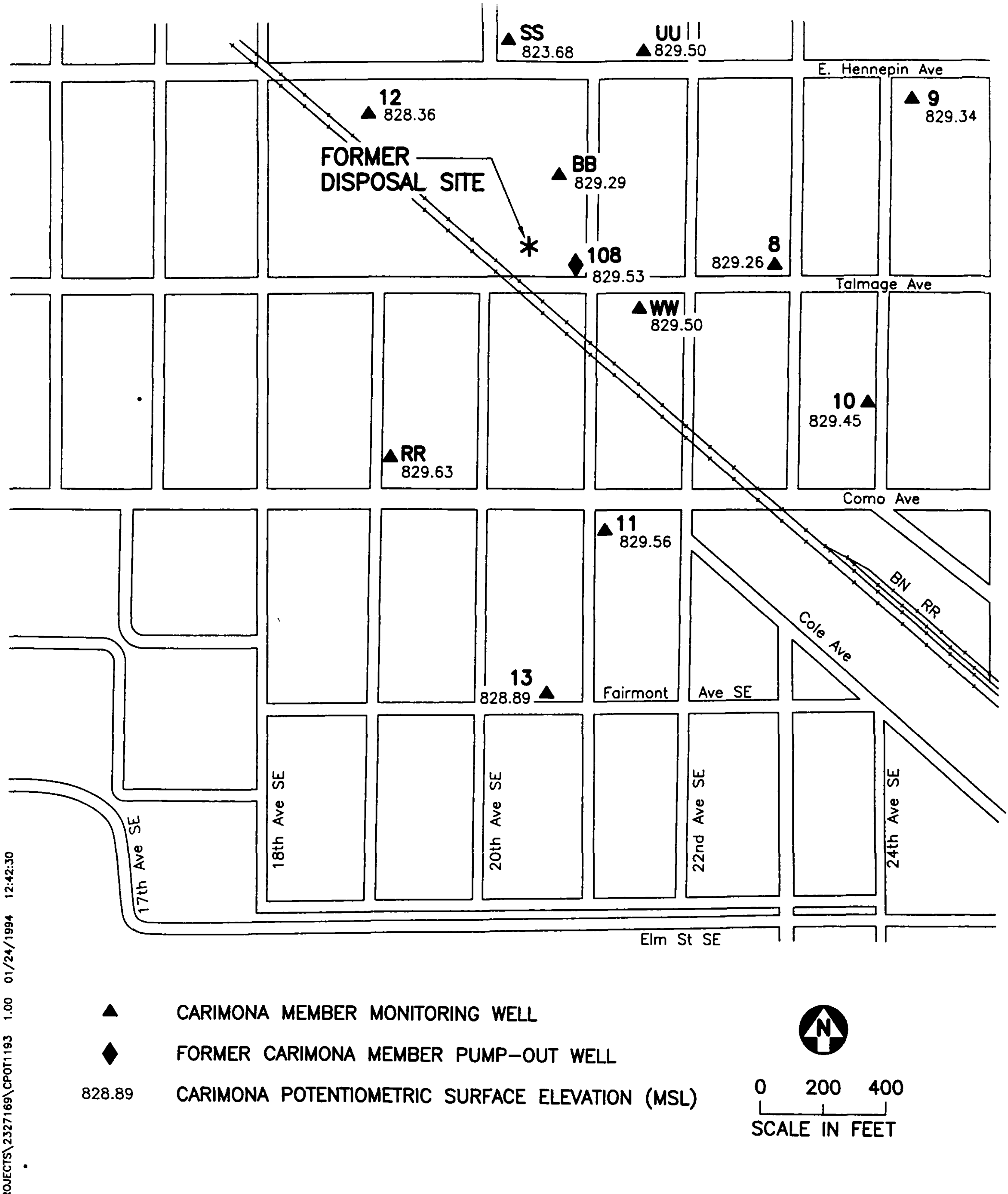
Jan Moss C:\PROJECTS\2327169\GM93-F7 1.00 01/24/1994 13:25:09



Jan Moss C:\PROJECTS\2327169\CPOT593 1.00 01/24/1994 12:41:39

Figure 9

CARIMONA MEMBER
POTENTIOMETRIC SURFACE ELEVATIONS
MAY 1993



▲ CARIMONA MEMBER MONITORING WELL

◆ FORMER CARIMONA MEMBER PUMP-OUT WELL

828.89 CARIMONA POTENTIOMETRIC SURFACE ELEVATION (MSL)

Jan Moss C:\PROJECTS\2327169\CPOT1193 1.00 01/24/1994 12:42:30

Figure 10

CARIMONA MEMBER
POTENTIOMETRIC SURFACE ELEVATIONS
NOVEMBER 1993

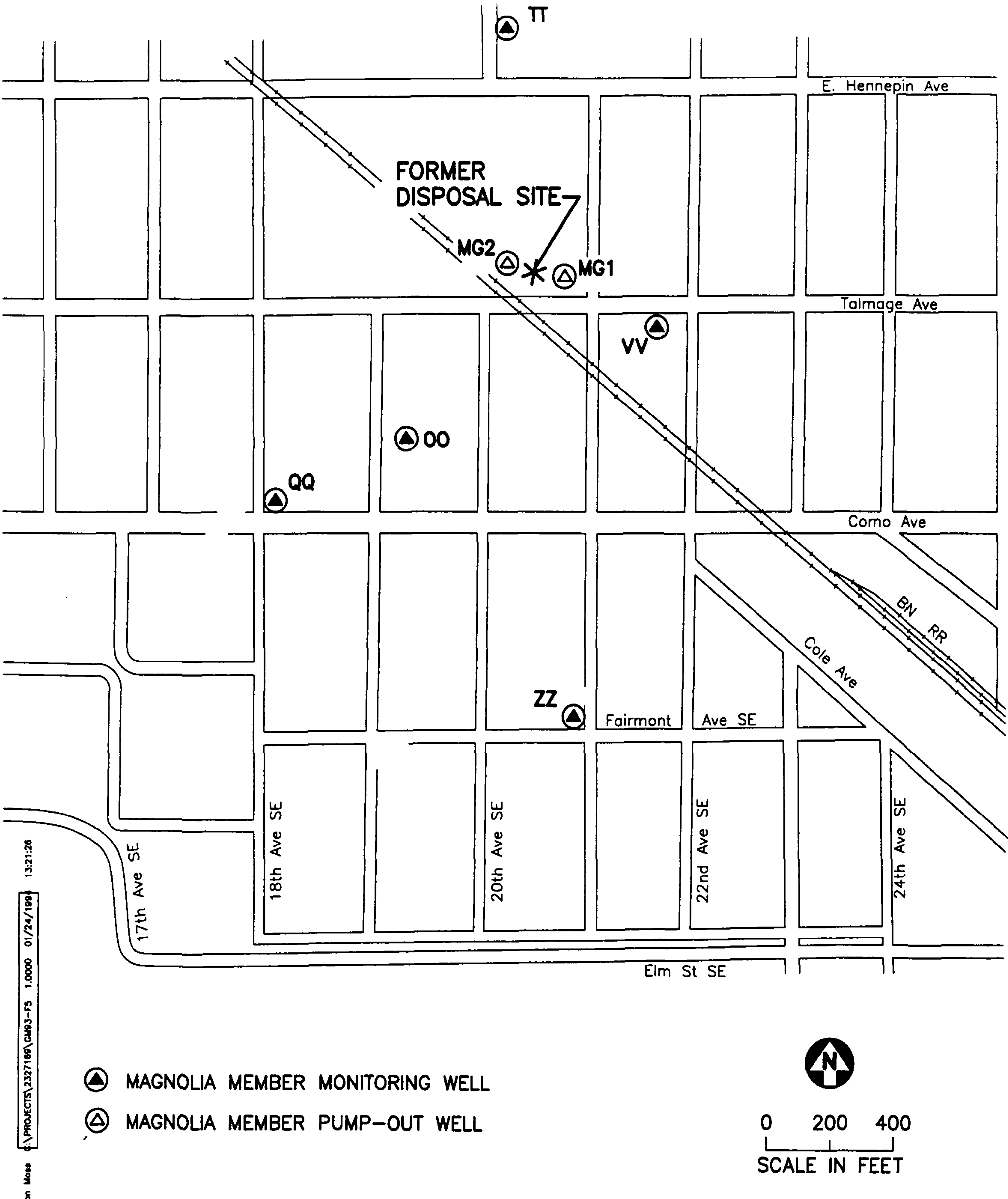
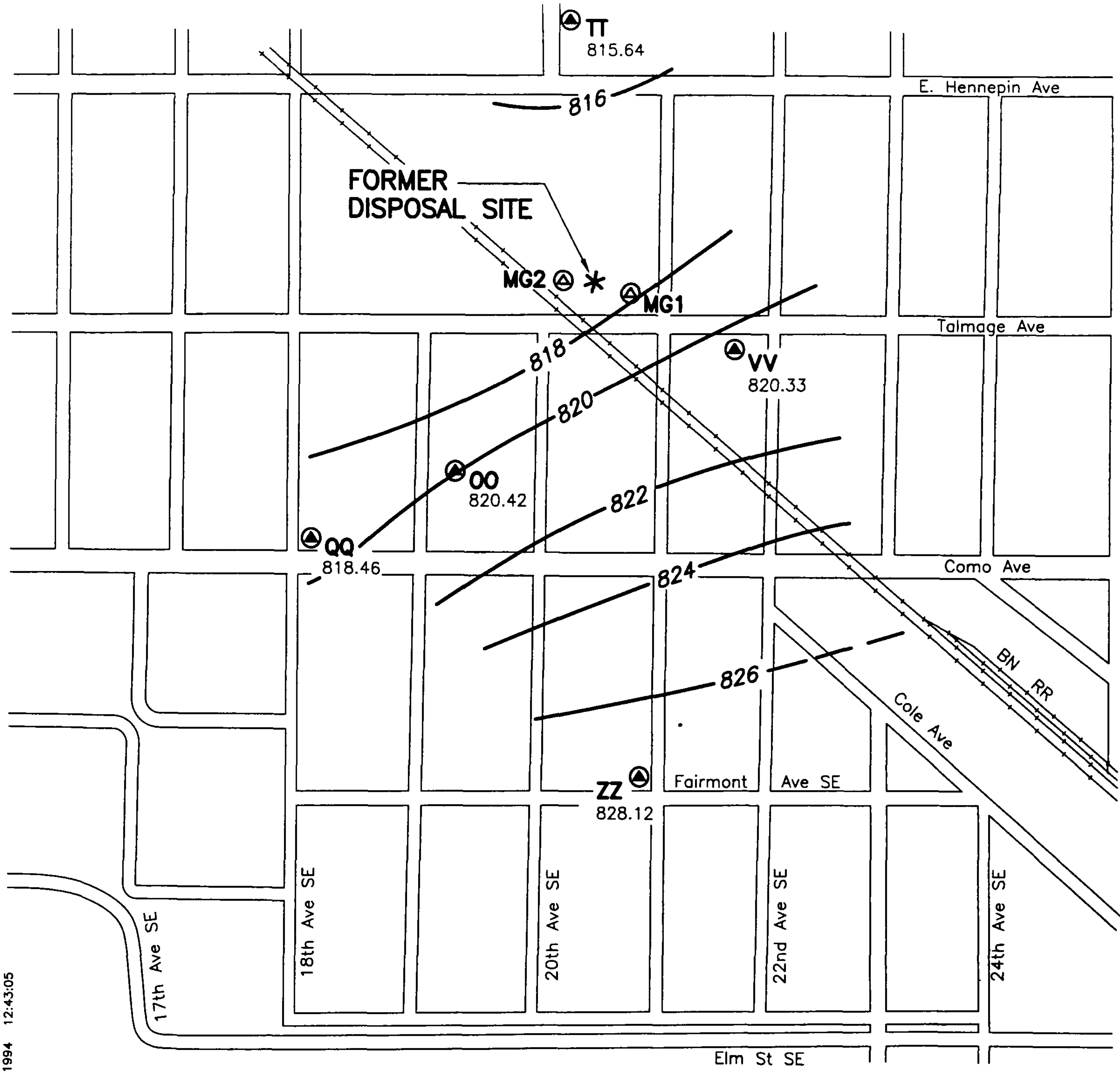


Figure 11
1993 MONITORING LOCATIONS
MAGNOLIA MEMBER



MAGNOLIA MEMBER MONITORING WELL

MAGNOLIA MEMBER PUMP-OUT WELL

828.12 MAGNOLIA MEMBER POTENTIOMETRIC SURFACE ELEVATION (MSL)

—826— MAGNOLIA MEMBER POTENTIOMETRIC SURFACE CONTOUR (MSL)

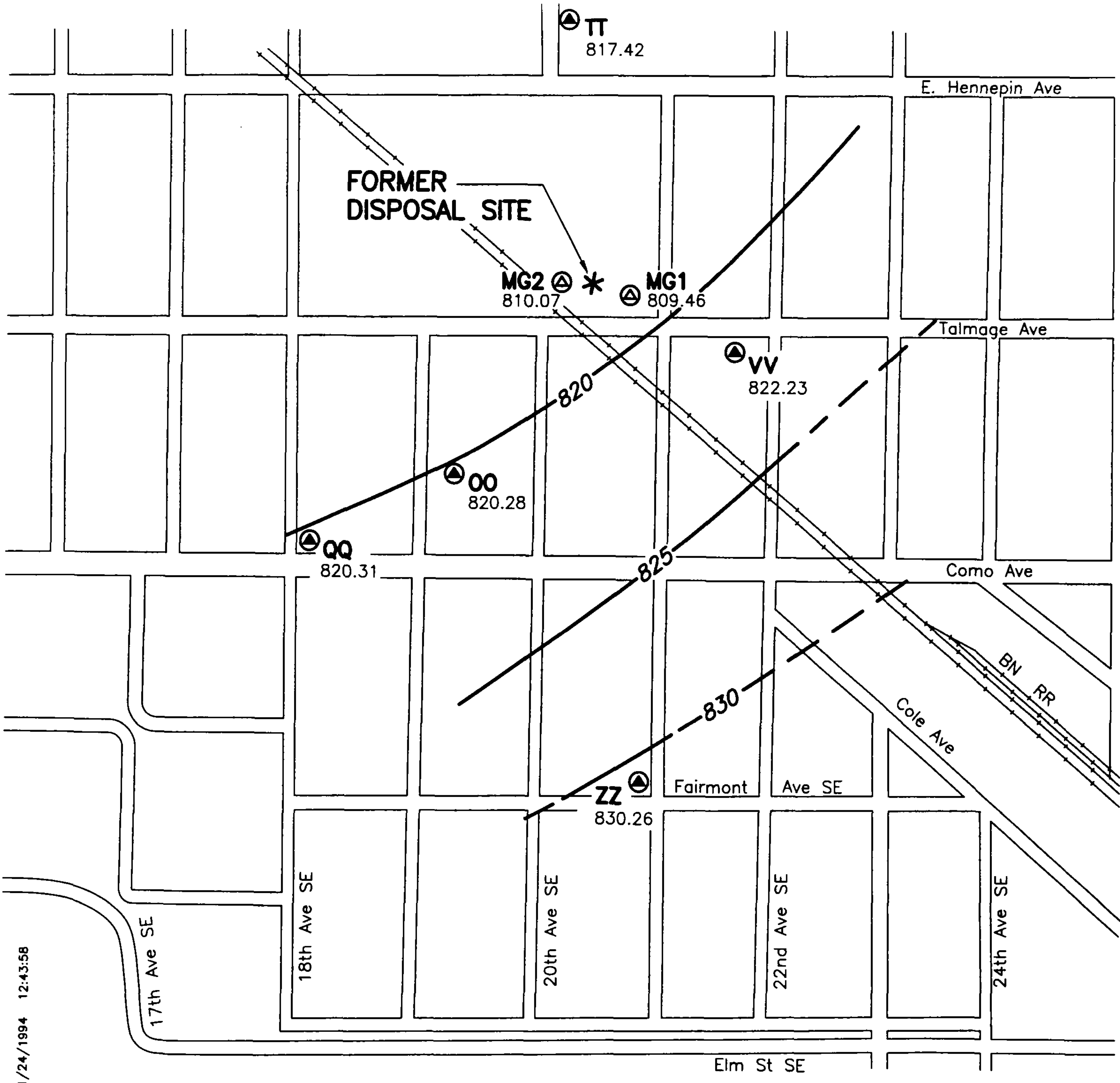
0 200 400

SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\MPOT593 1.00 01/24/1994 12:43:05

Figure 12

MAGNOLIA MEMBER
POTENTIOMETRIC SURFACE ELEVATIONS
MAY 1993



MAGNOLIA MEMBER MONITORING WELL

MAGNOLIA MEMBER PUMP-OUT WELL

830.26 MAGNOLIA MEMBER POTENTIOMETRIC SURFACE ELEVATION (MSL)

—830— MAGNOLIA MEMBER POTENTIOMETRIC SURFACE CONTOUR (MSL)

N

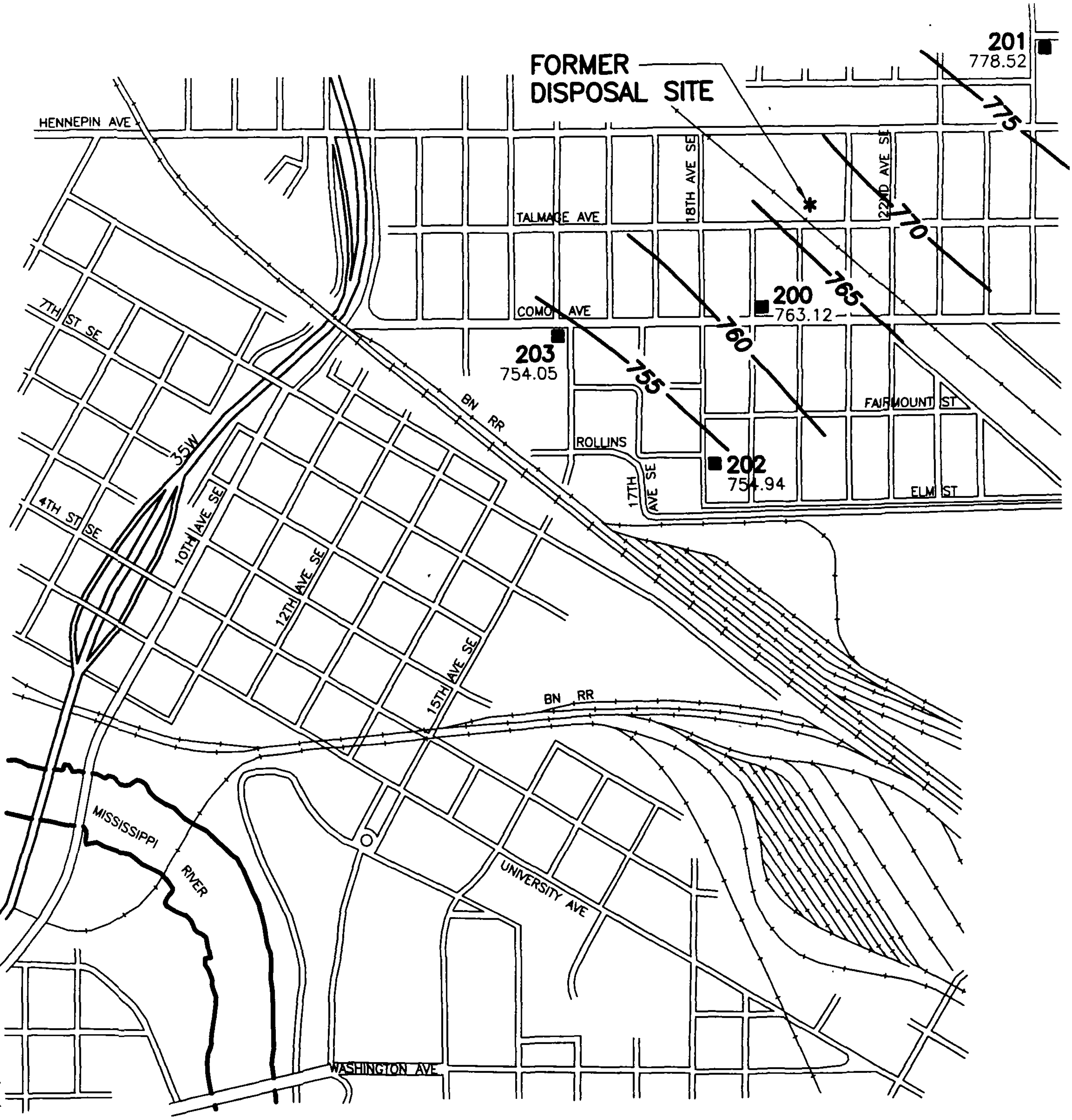
0 200 400
SCALE IN FEET

Figure 13

MAGNOLIA MEMBER
POTENTIOMETRIC SURFACE ELEVATIONS
NOVEMBER 1993

Jan Moss C:\PROJECTS\2327169\MPOT1193 1.00 01/24/1994 12:43:58

Figure 14
1993 MONITORING LOCATIONS
ST. PETER SANDSTONE



■ ST. PETER SANDSTONE MONITORING WELL

754.24 ST. PETER SANDSTONE POTENTIOMETRIC SURFACE ELEVATION (MSL)

—755— ST. PETER SANDSTONE POTENTIOMETRIC SURFACE CONTOUR (MSL)

N

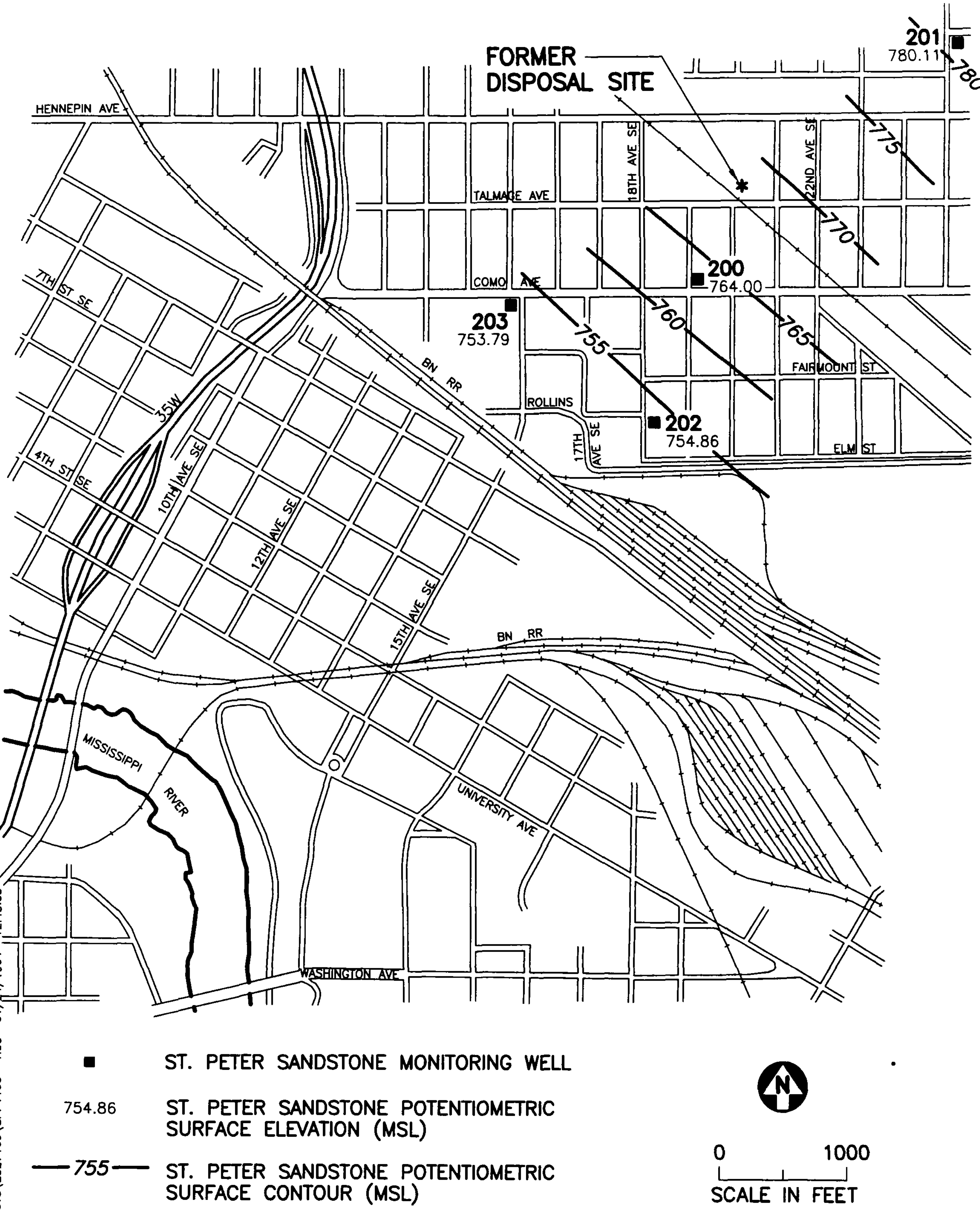
0 1000

SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\SPP593 1.00 01/24/1994 12:44:54

Figure 15

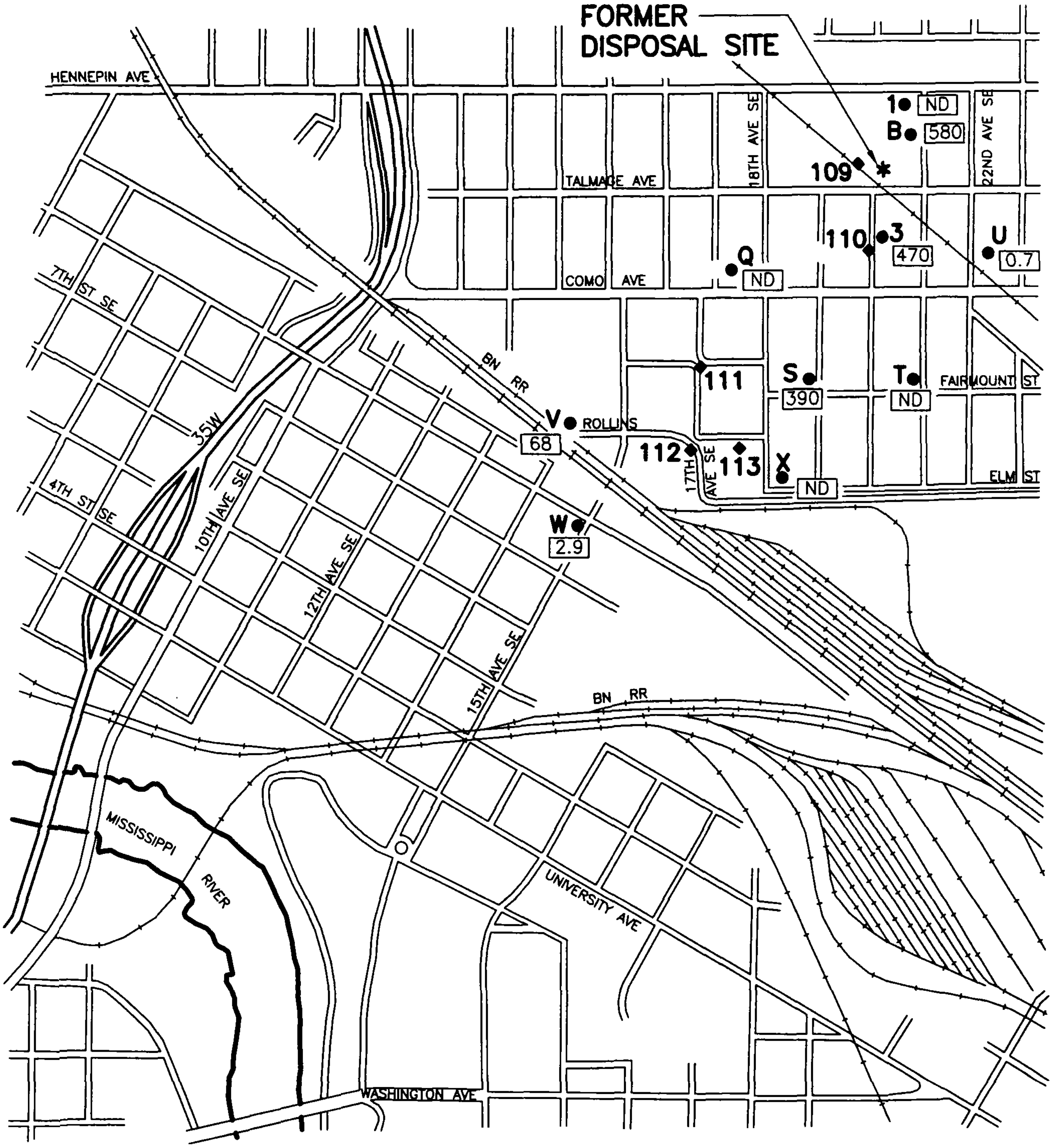
ST. PETER SANDSTONE
POTENTIOMETRIC SURFACE ELEVATIONS
MAY 1993



Jan Moss C:\PROJECTS\2327169\SPP1193 1.00 01/24/1994 12:45:33

Figure 16

ST. PETER SANDSTONE
POTENTIOMETRIC SURFACE ELEVATIONS
NOVEMBER 1993



● GLACIAL DRIFT MONITORING WELL

◆ SITE AND DOWNGRADIENT GLACIAL DRIFT PUMP-OUT WELL

68 TRICHLOROETHENE CONCENTRATION (TCE) (ug/L)

ND NOT DETECTED

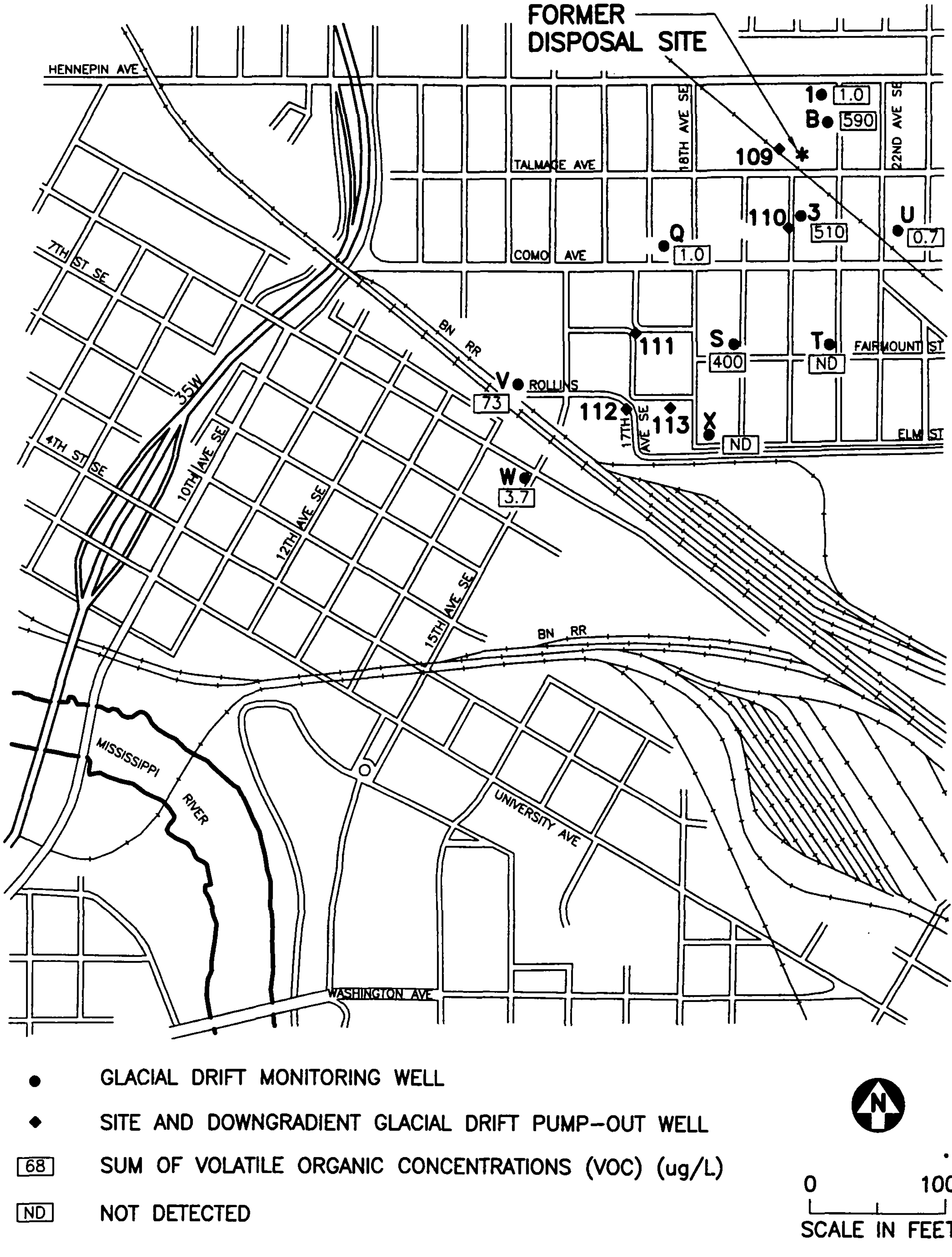
N

0 1000
SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\GWQTC593 1.00 01/24/1994 12:46:17

Figure 17

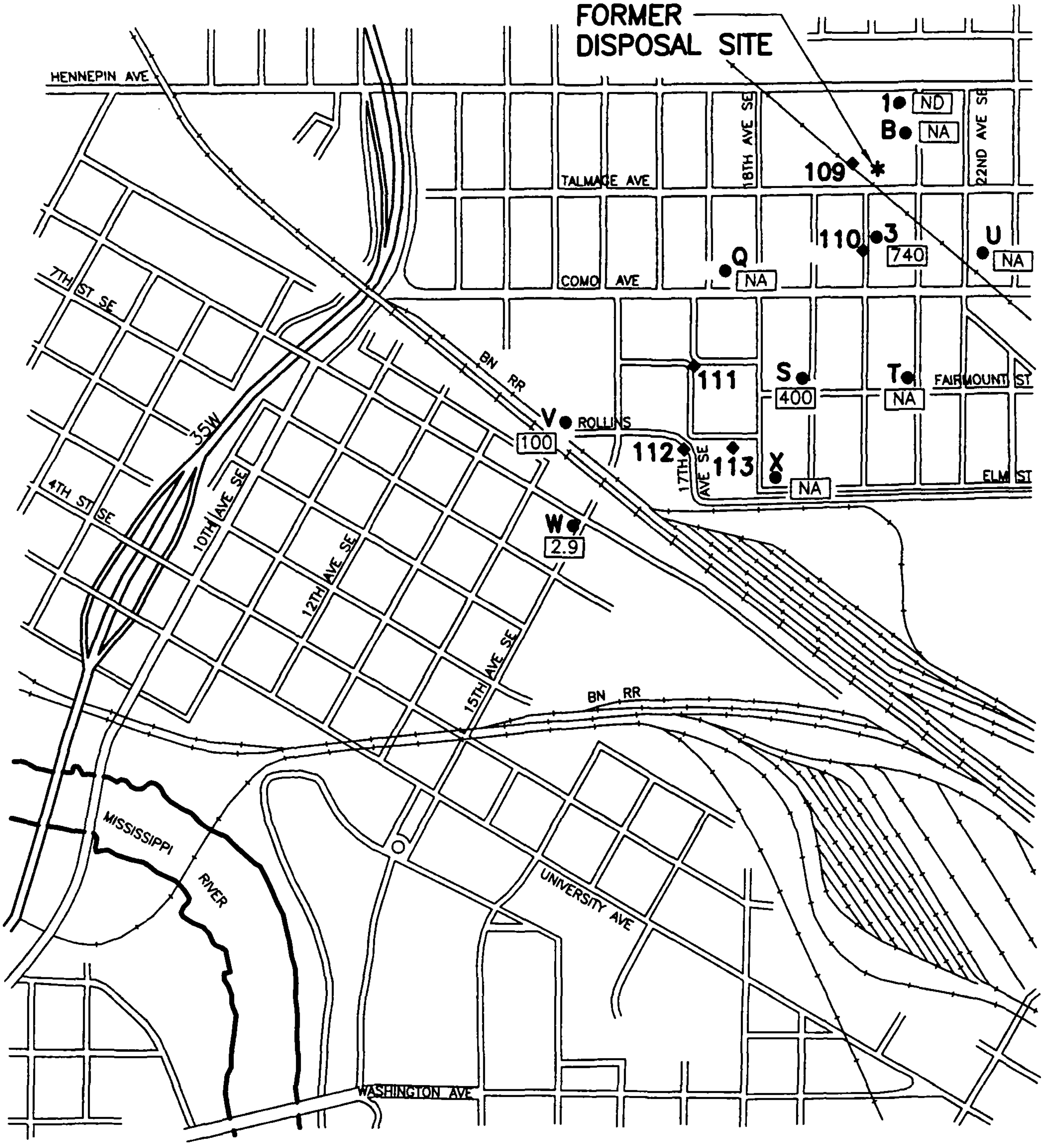
GLACIAL DRIFT AQUIFER
WATER QUALITY (TCE)
MAY 1993



Jan Moss C:\PROJECTS\2327169\GWQ593 1.00 01/24/1994 12:47:13

Figure 18

GLACIAL DRIFT AQUIFER
WATER QUALITY (VOC)
MAY 1993



● GLACIAL DRIFT MONITORING WELL

◆ SITE AND DOWNGRADIENT GLACIAL DRIFT PUMP-OUT WELL

[68] TRICHLOROETHENE CONCENTRATION (TCE) (ug/L)

[ND] NOT DETECTED

[NA] NOT ANALYZED

N

0 1000
SCALE IN FEET

Figure 19

GLACIAL DRIFT AQUIFER
WATER QUALITY (TCE)
NOVEMBER 1993

Jan Moss C:\PROJECTS\2327169\GWQ1193 1.00 01/24/1994 12:47:53

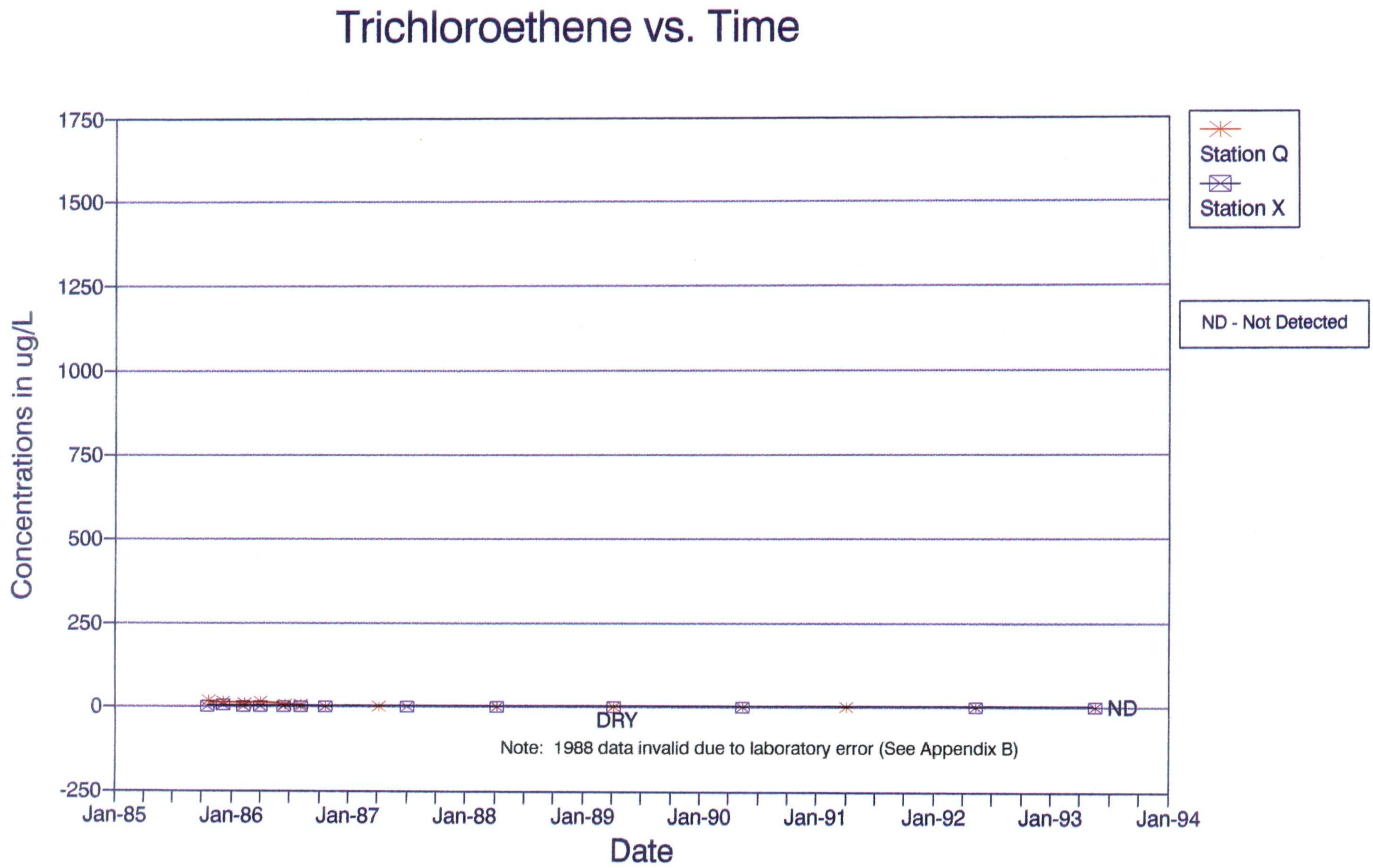


FIGURE 20
GLACIAL DRIFT WELLS
TCE CONCENTRATIONS

1985-1993

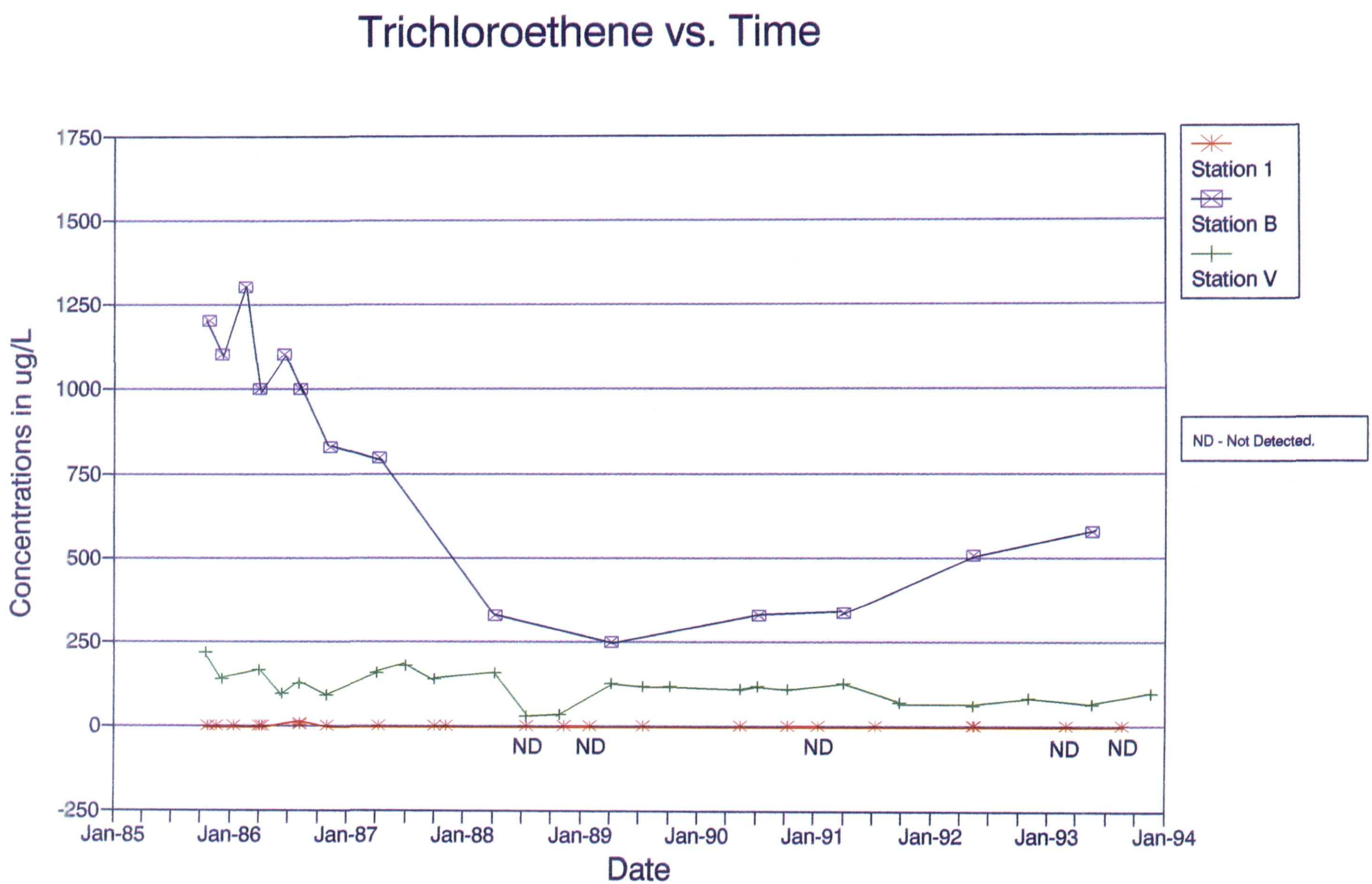


FIGURE 20 (cont.)
GLACIAL DRIFT WELLS
TCE CONCENTRATIONS
1985-1993

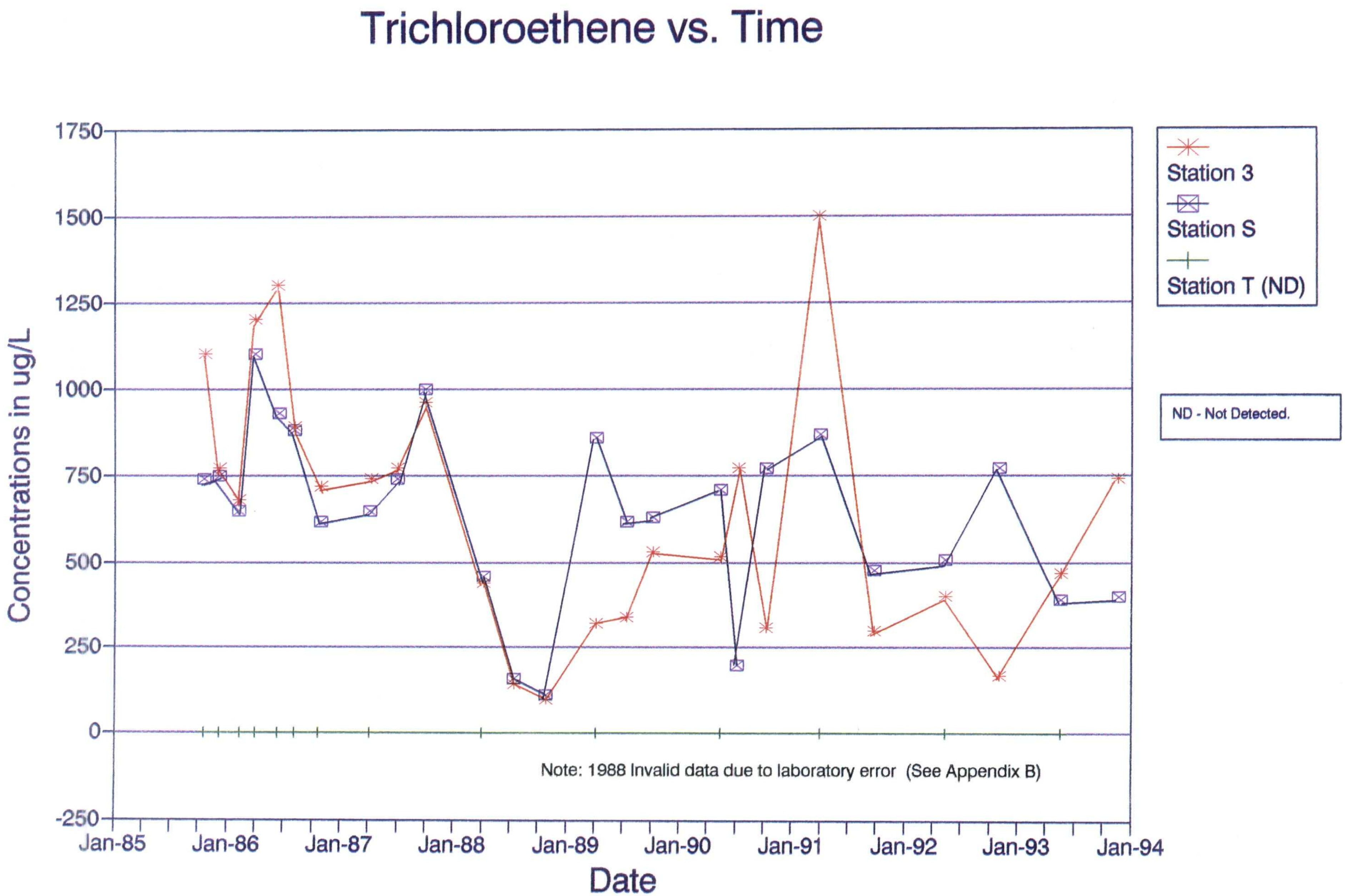
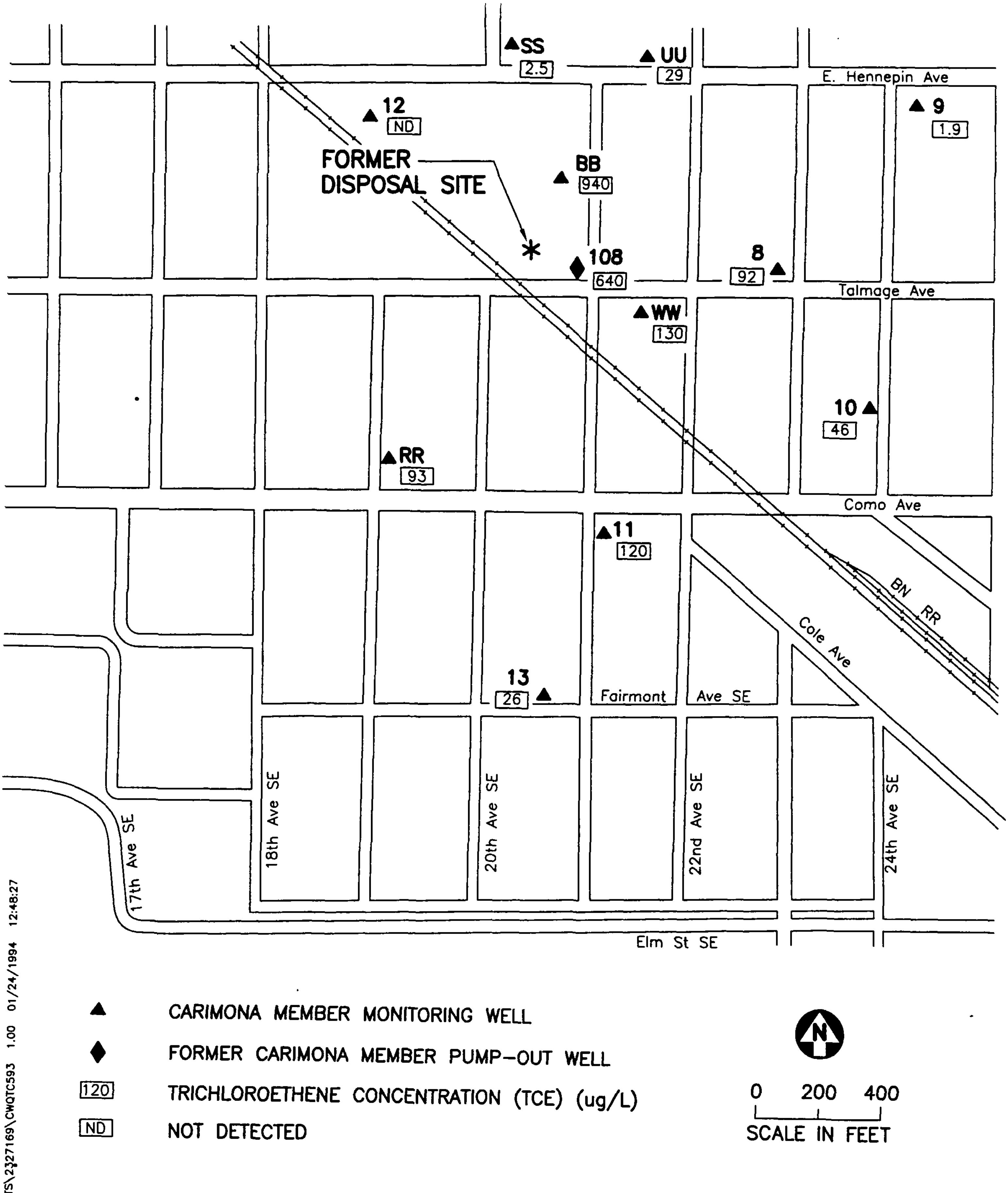


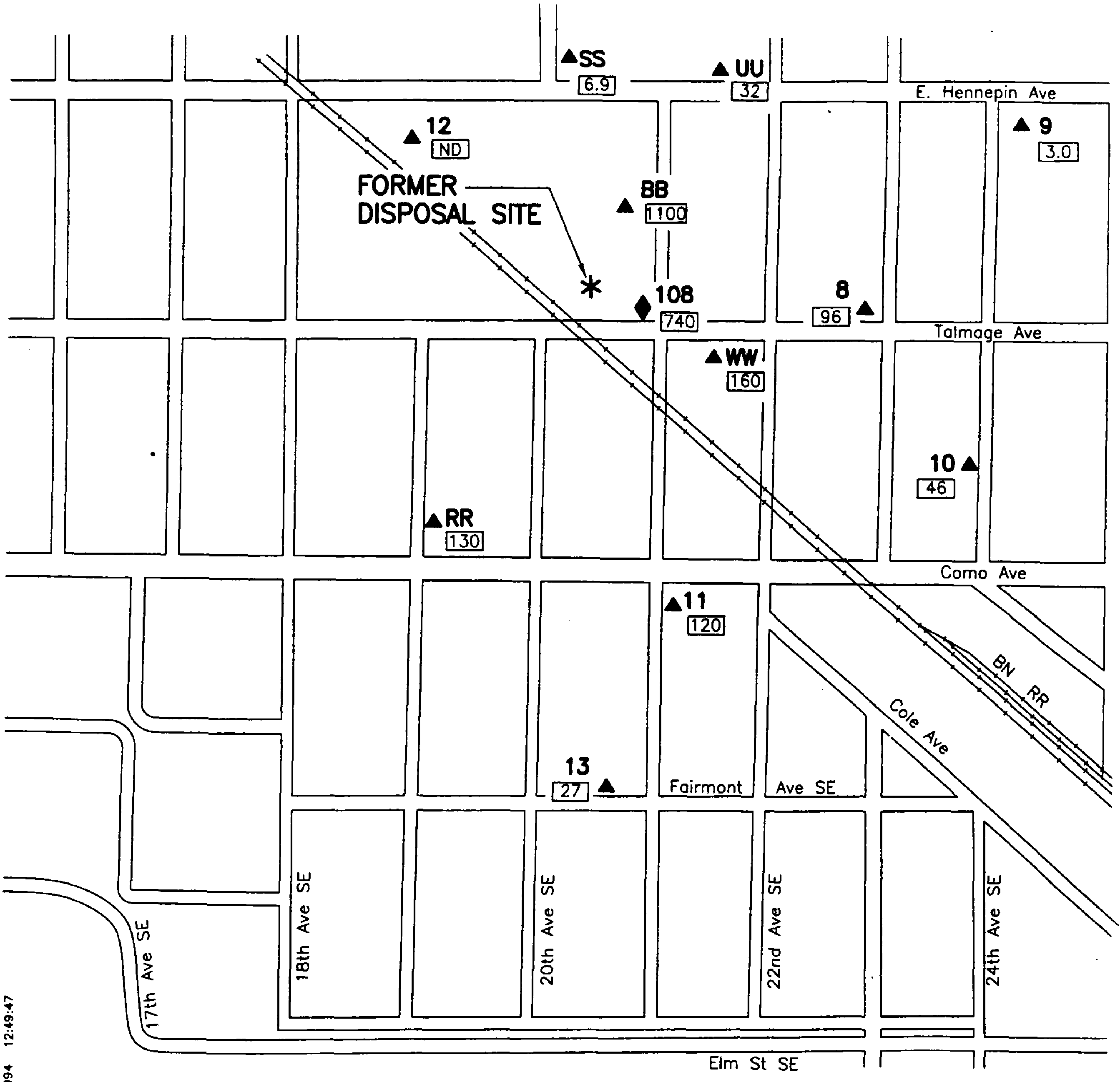
FIGURE 20 (cont.)
GLACIAL DRIFT WELLS
TCE CONCENTRATIONS
1985-1993



Jan Moss C:\PROJECTS\2327169\CWQTC593 1.00 01/24/1994 12:48:27

Figure 21

CARIMONA MEMBER
WATER QUALITY (TCE)
MAY 1993



▲ CARIMONA MEMBER MONITORING WELL

◆ FORMER CARIMONA MEMBER PUMP-OUT WELL

[120] SUM OF VOLATILE ORGANIC CONCENTRATIONS (VOC) (ug/L)

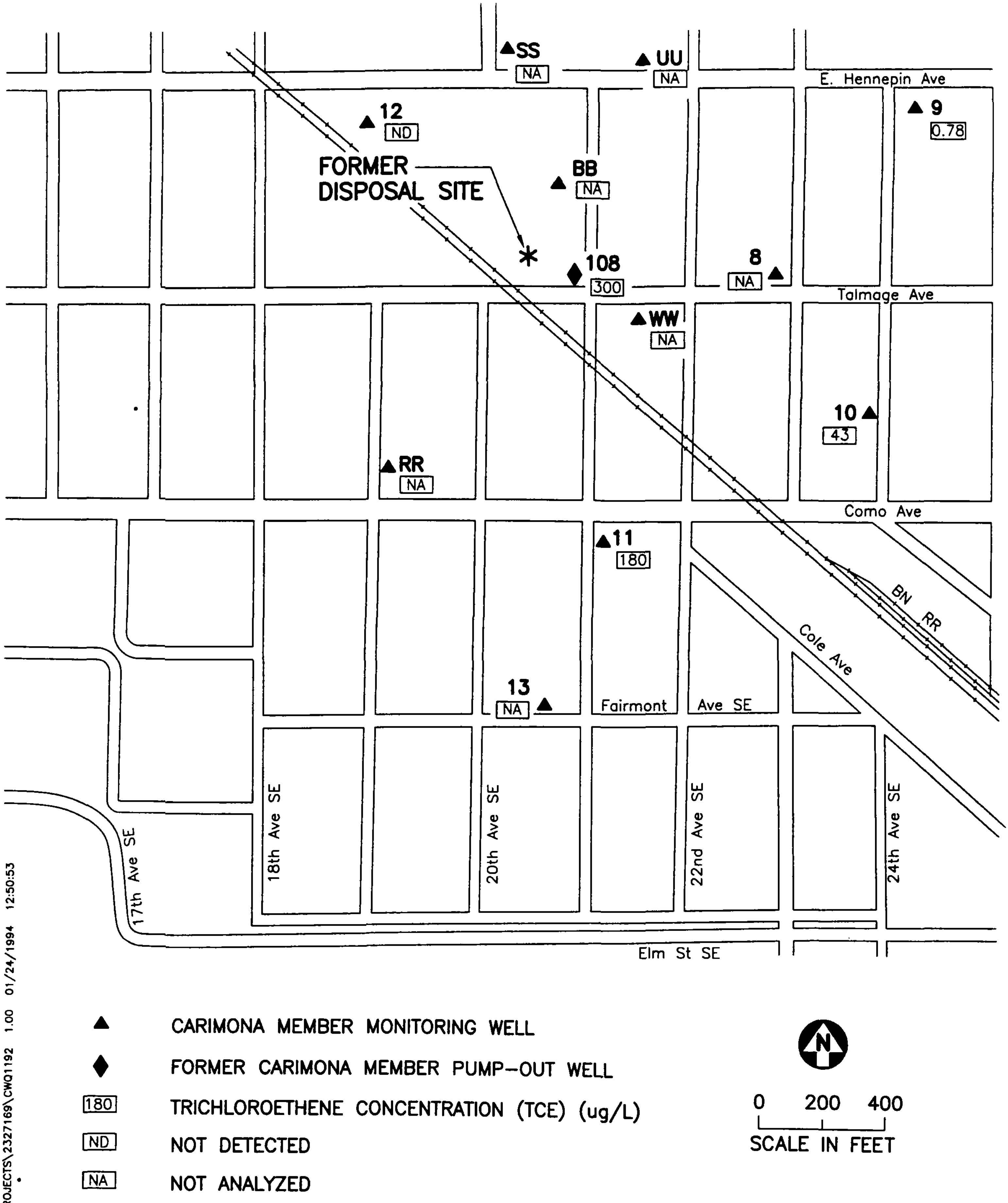
[ND] NOT DETECTED

0 200 400
SCALE IN FEET

Figure 22

CARIMONA MEMBER
WATER QUALITY (VOC)
MAY 1993

Jan Moss C:\PROJECTS\2327169\CWQ593 1.00 01/24/1994 12:49:47



Jan Moss C:\PROJECTS\2327169\CWQ1192 1.00 01/24/1994 12:50:53

Figure 23

CARIMONA MEMBER
WATER QUALITY (TCE)
NOVEMBER 1993

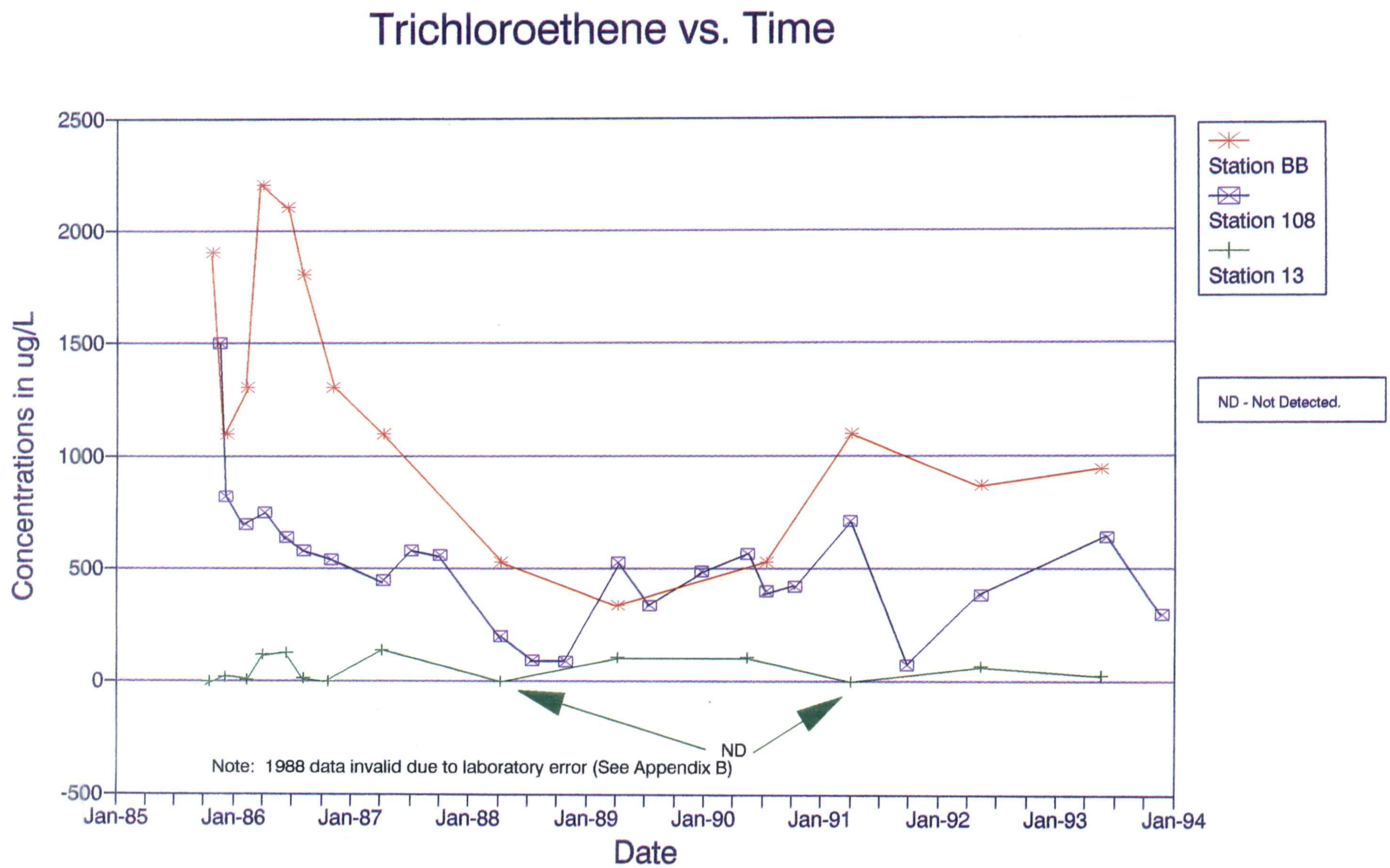


FIGURE 24
CARIMONA MEMBER WELLS
TCE CONCENTRATIONS

1985-1993

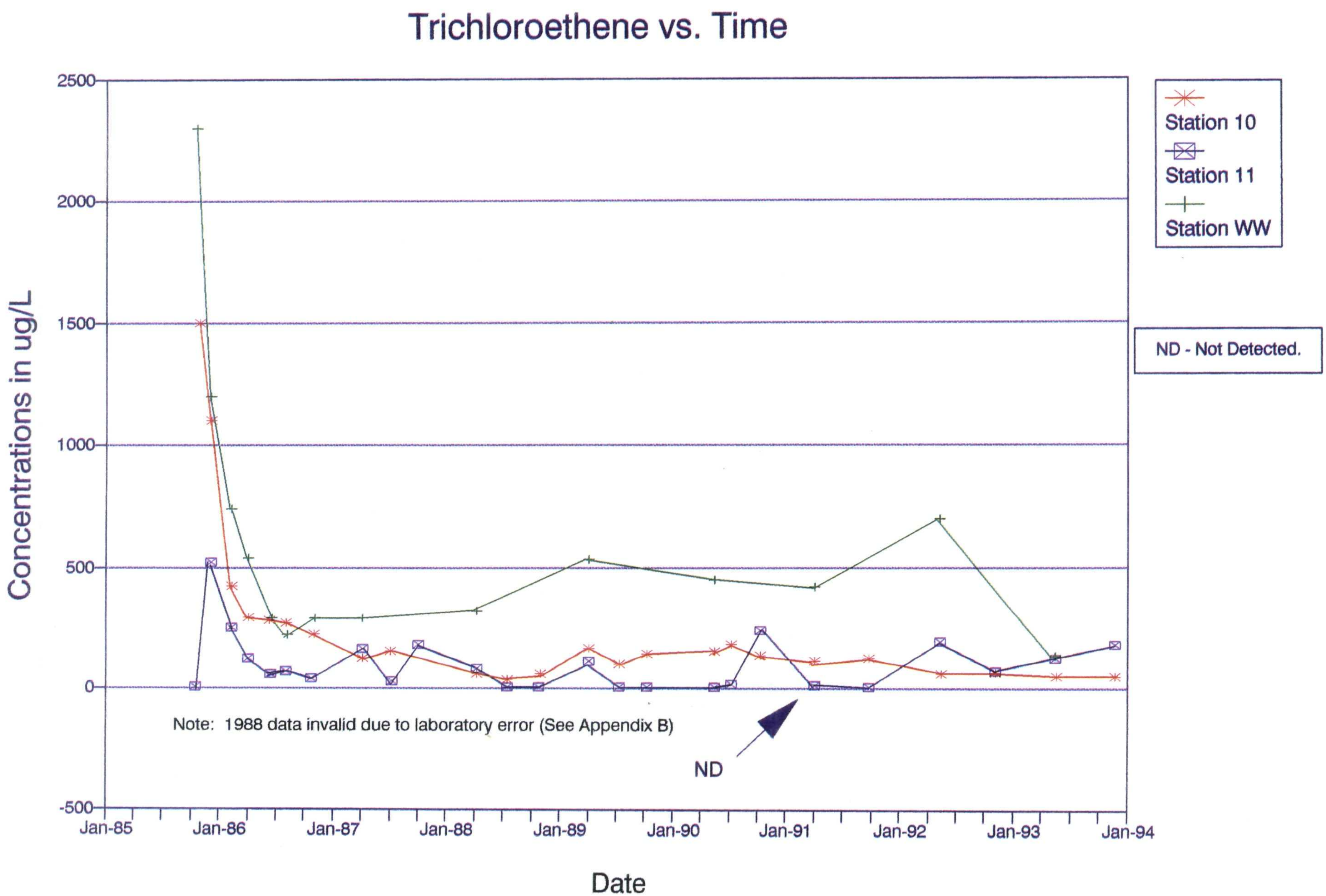


FIGURE 24 (cont.)
CARIMONA MEMBER WELLS
TCE CONCENTRATIONS
1985-1993

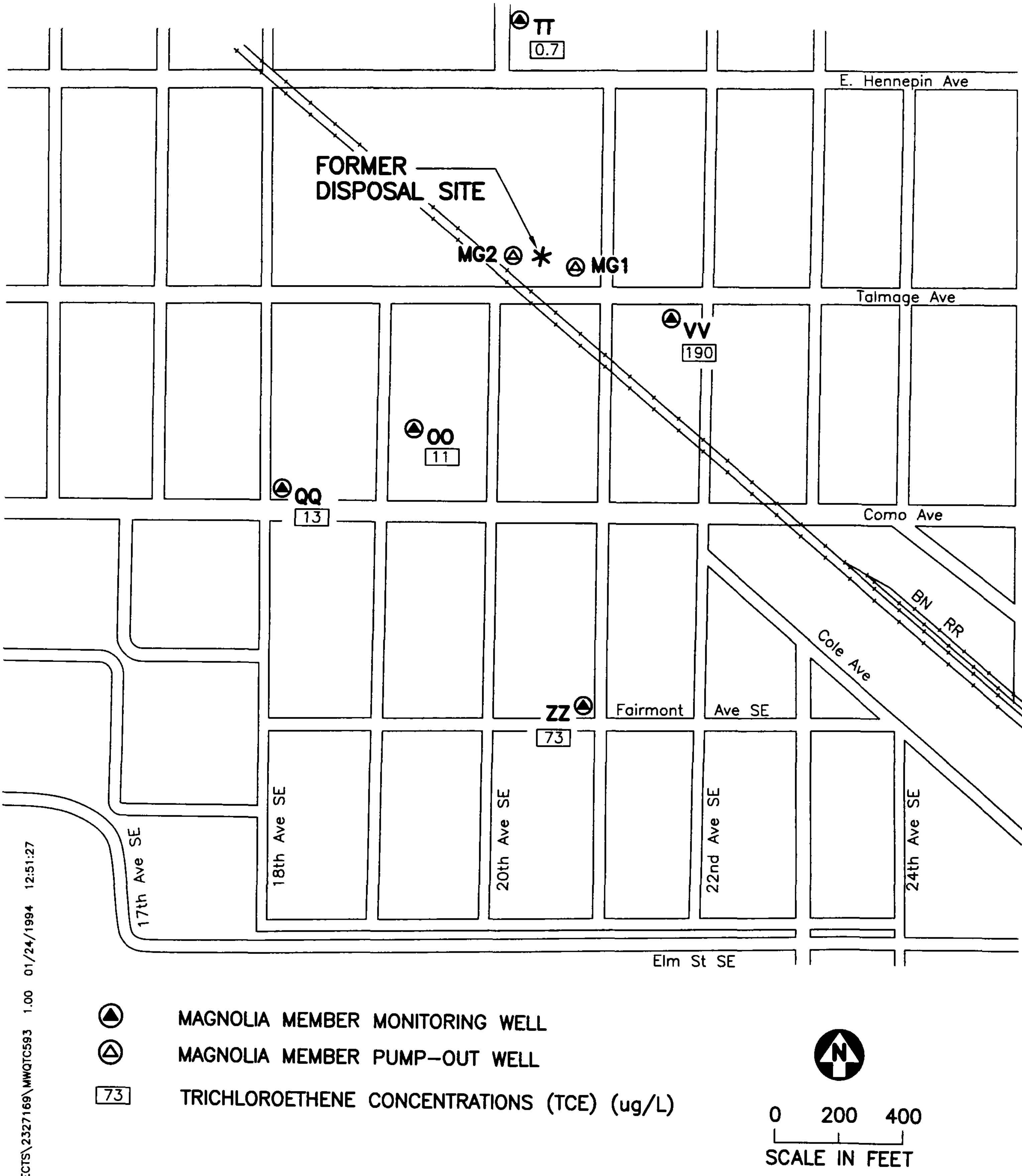
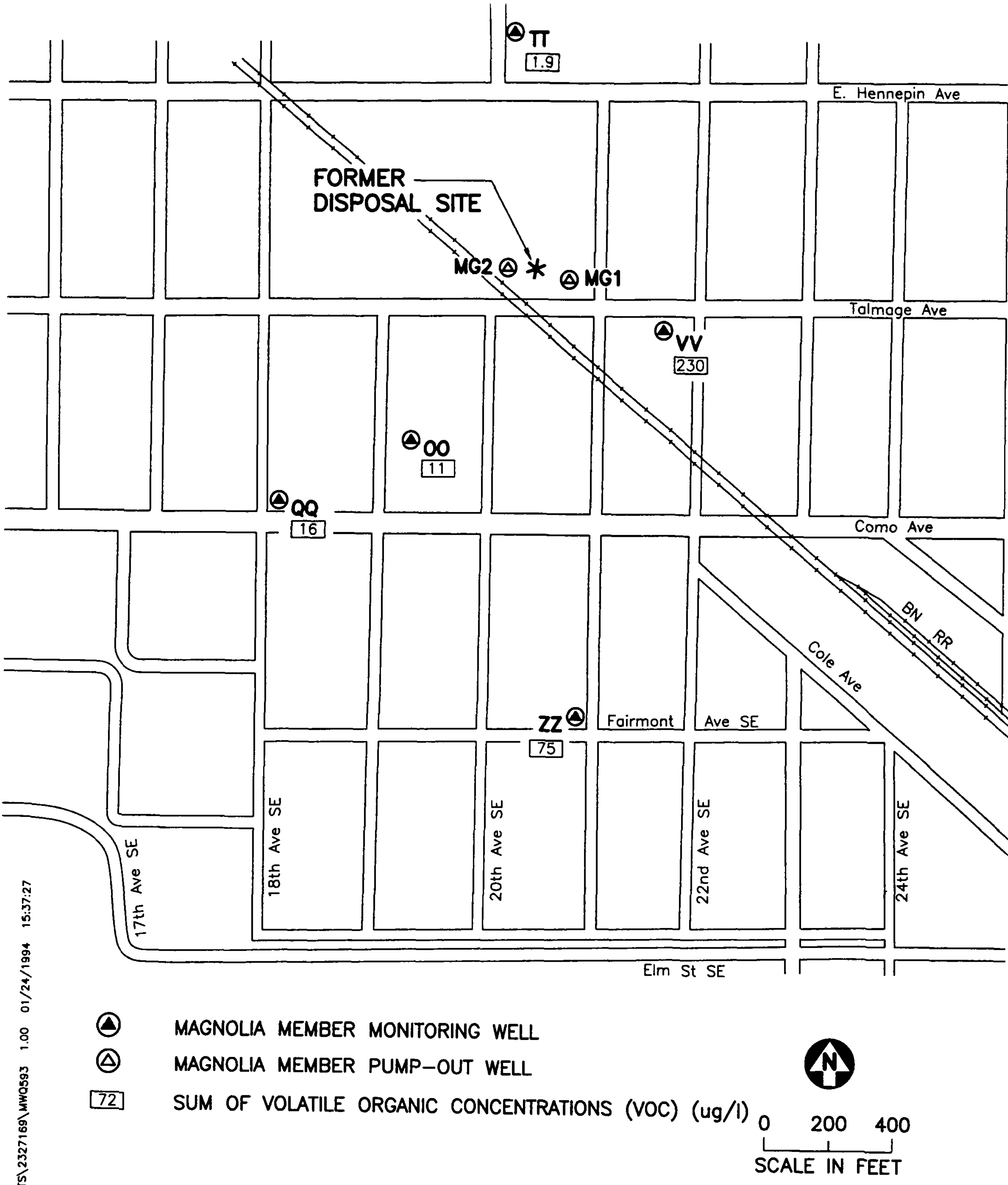


Figure 25

MAGNOLIA MEMBER
WATER QUALITY (TCE)
MAY 1993

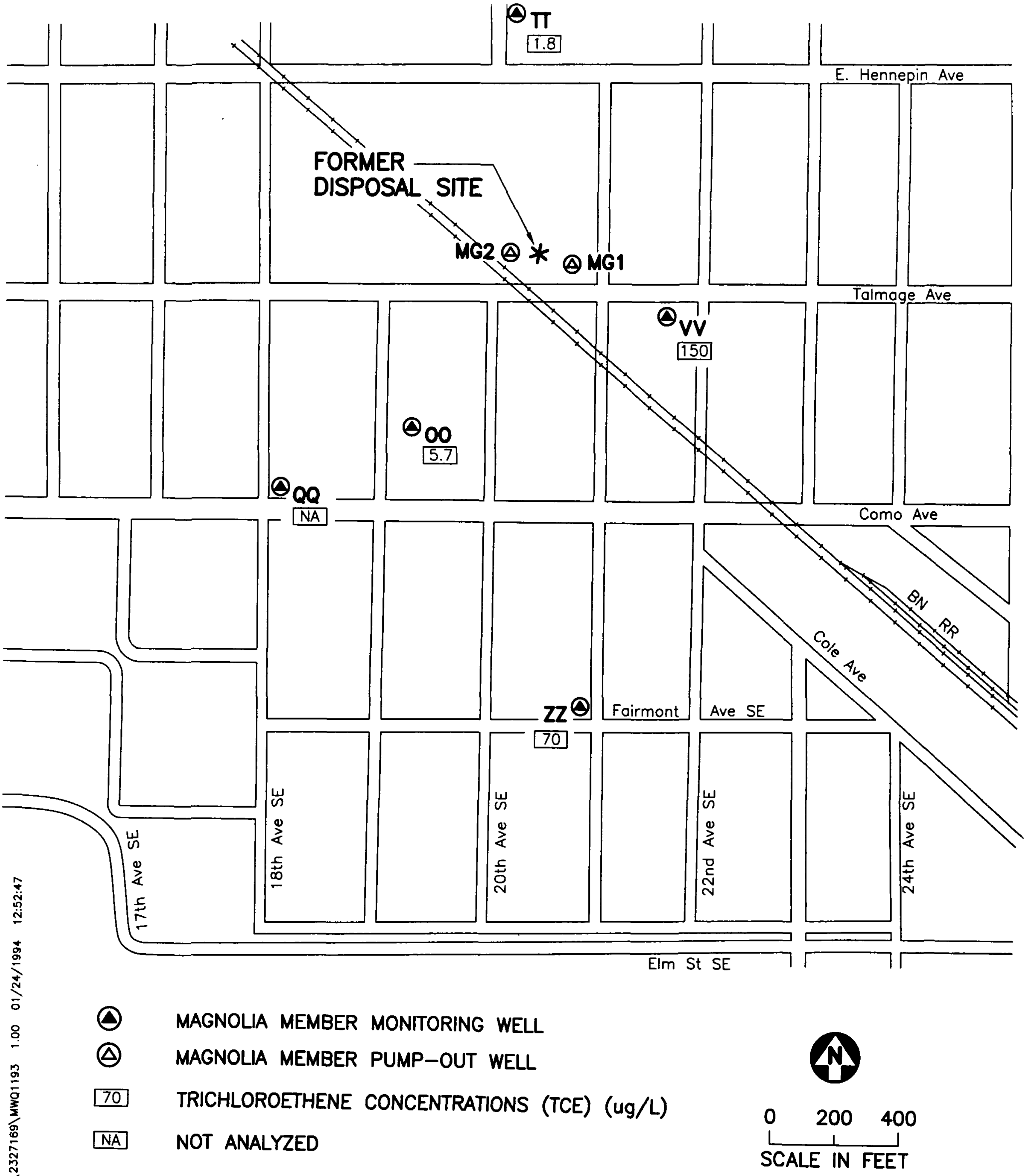
Jan Moss C:\PROJECTS\2327169\MWQTC593 1.00 01/24/1994 12:51:27



Jan Moss C:\PROJECTS\2327169\MWQ593 1.00 01/24/1994 15:37:27

Figure 26

MAGNOLIA MEMBER
WATER QUALITY (VOC)
MAY 1993



Jan Moss C:\PROJECTS\2327169\MWQ1193 1.00 01/24/1994 12:52:47

Figure 27

MAGNOLIA MEMBER
WATER QUALITY (TCE)
NOVEMBER 1993

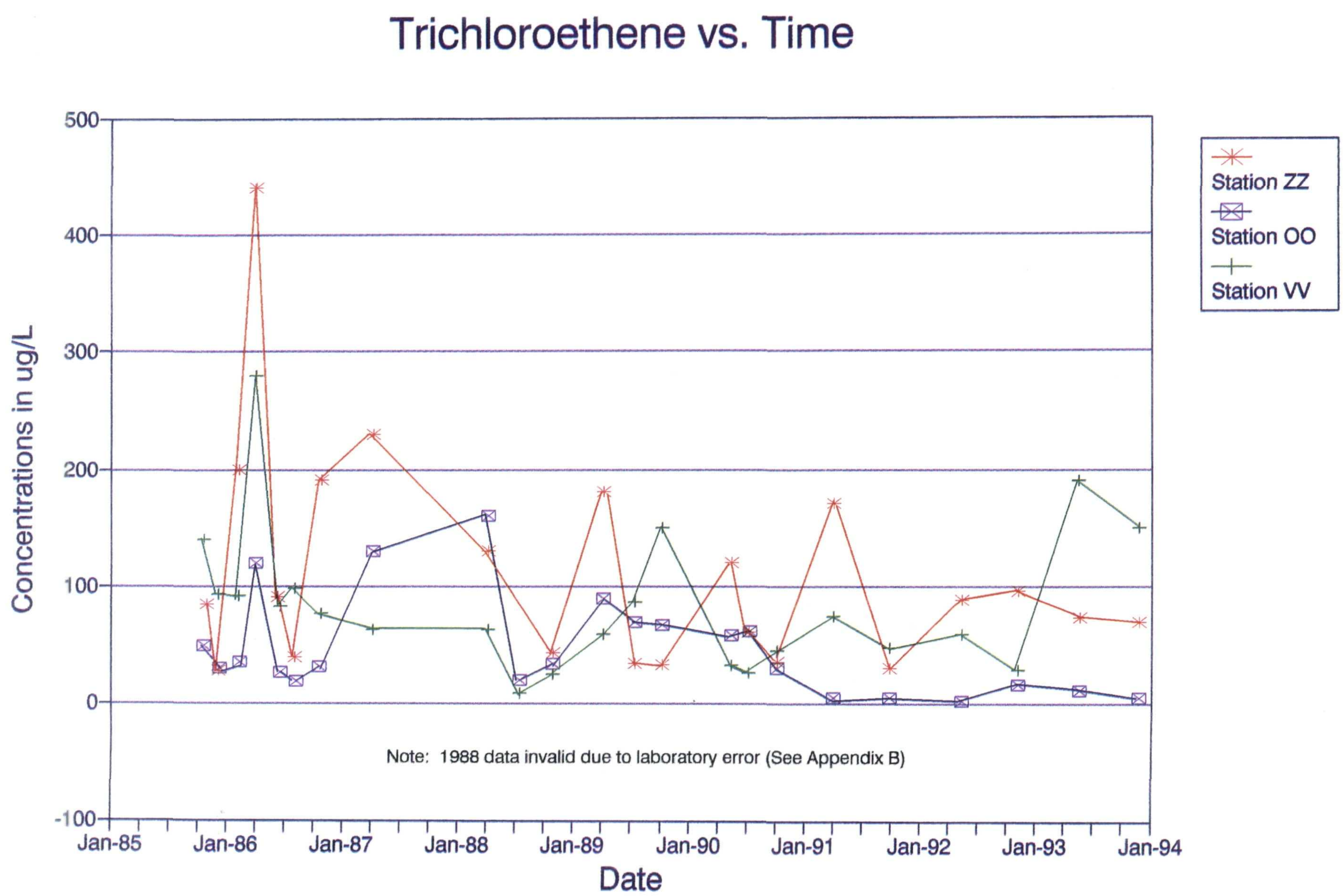


FIGURE 28
MAGNOLIA MEMBER WELLS
TCE CONCENTRATIONS
1985-1993

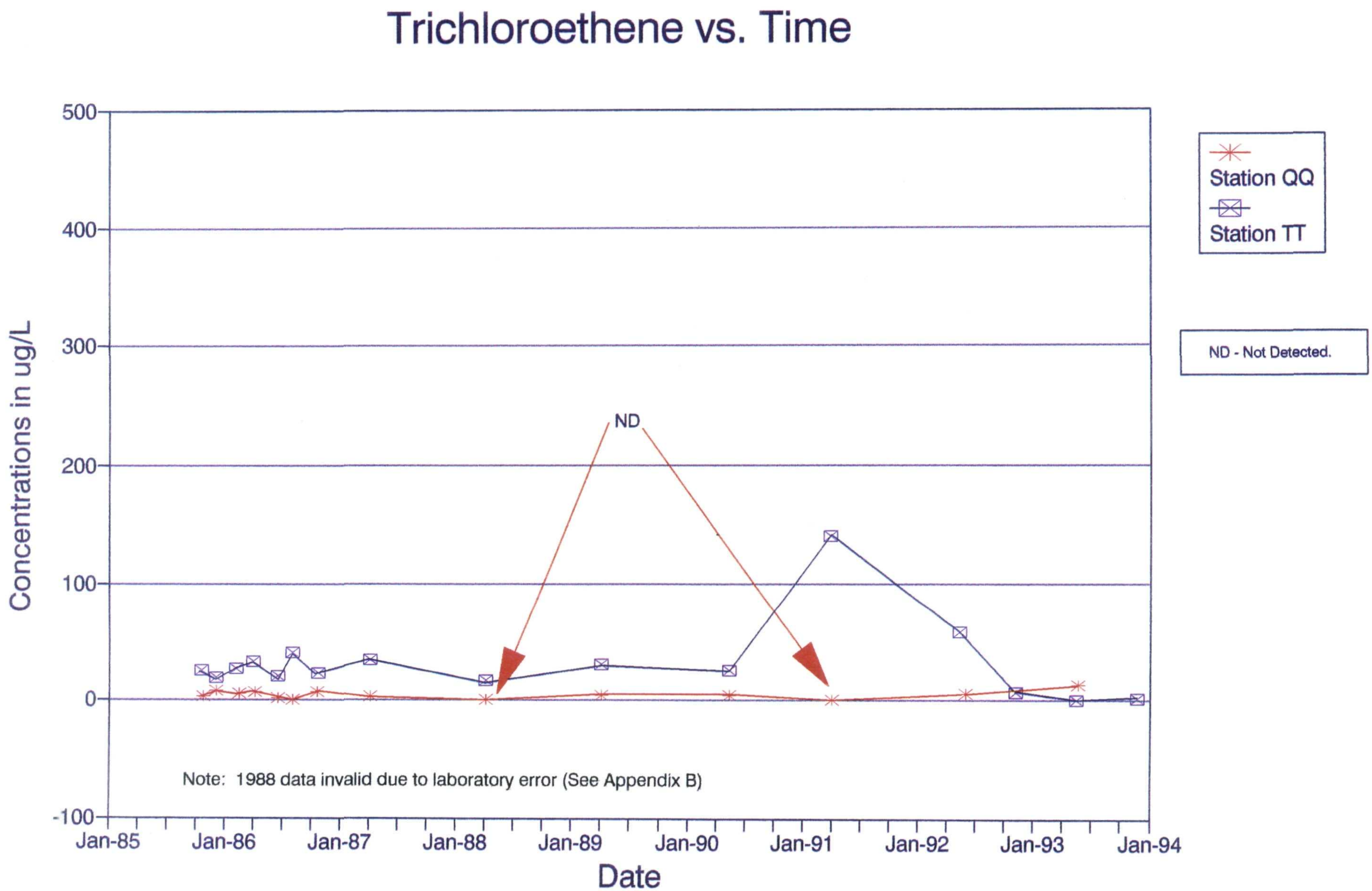
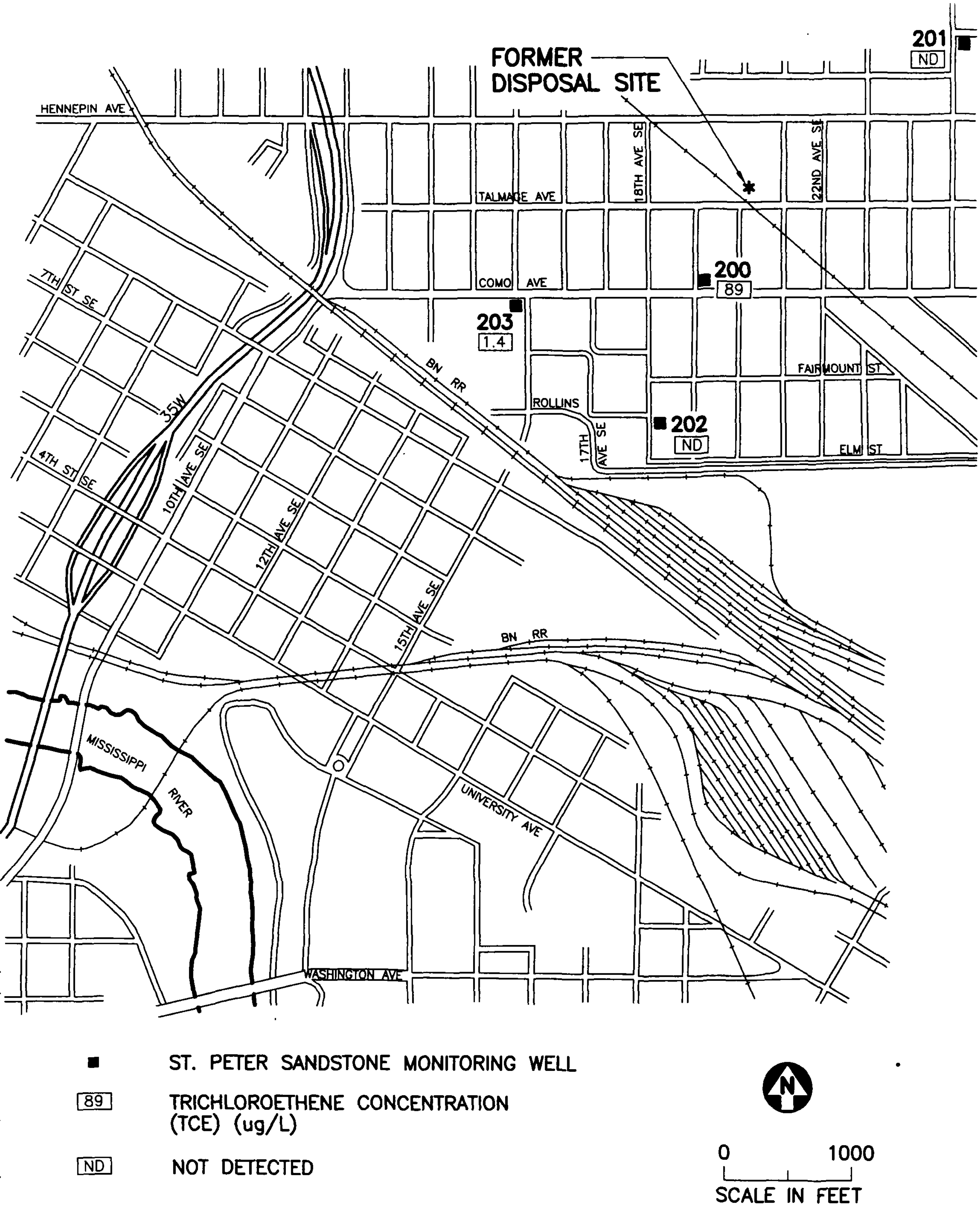


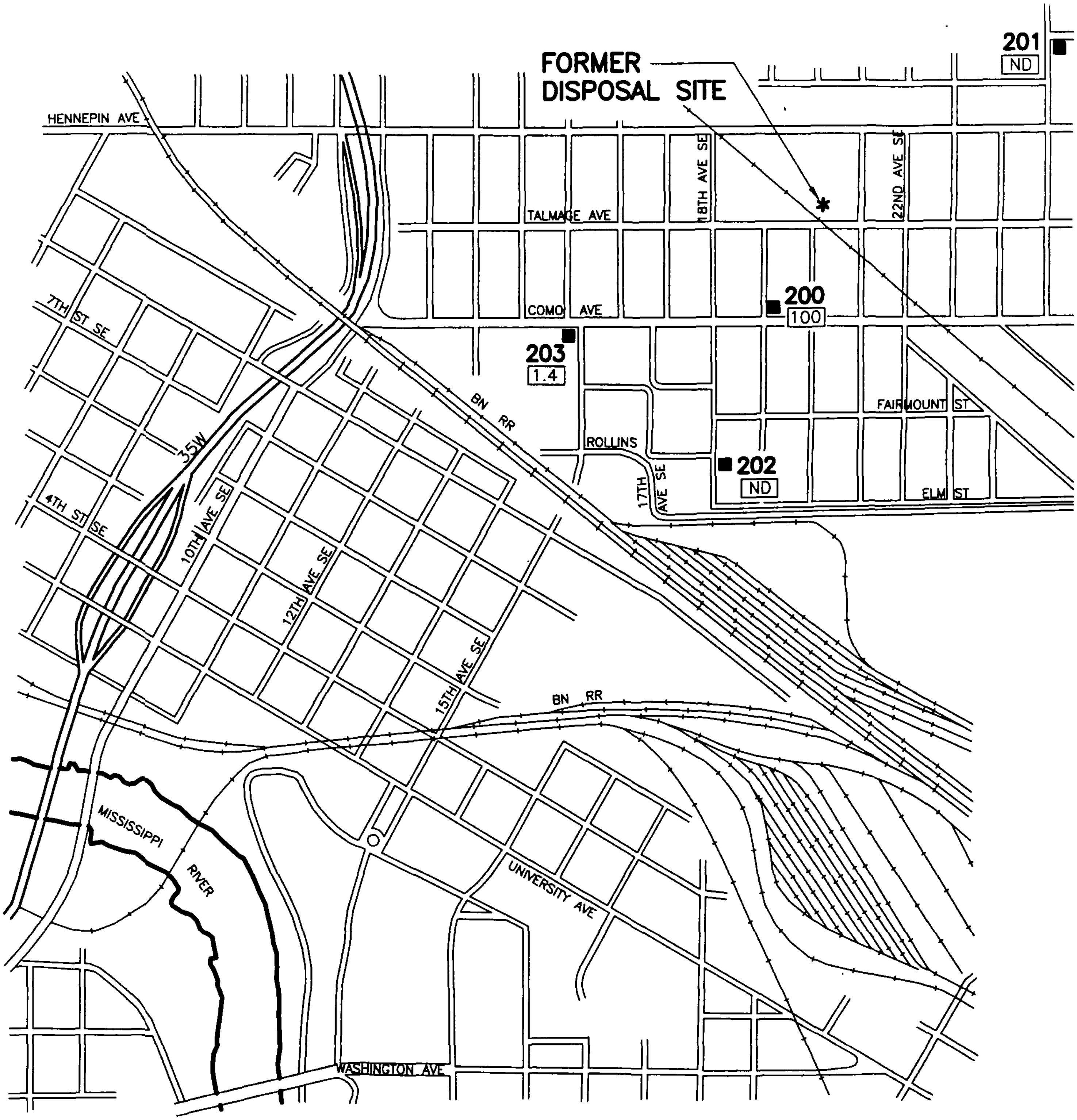
FIGURE 28 (cont.)
MAGNOLIA MEMBER WELLS
TCE CONCENTRATIONS
1985-1993



Jan Moss C:\PROJECTS\2327169\SPWQT593 1.00 01/24/1994 12:54:07

Figure 29

ST. PETER SANDSTONE
WATER QUALITY (TCE)
MAY 1993



■ ST. PETER SANDSTONE MONITORING WELL

[100] SUM OF VOLATILE ORGANIC CONCENTRATIONS (VOC) (ug/L)

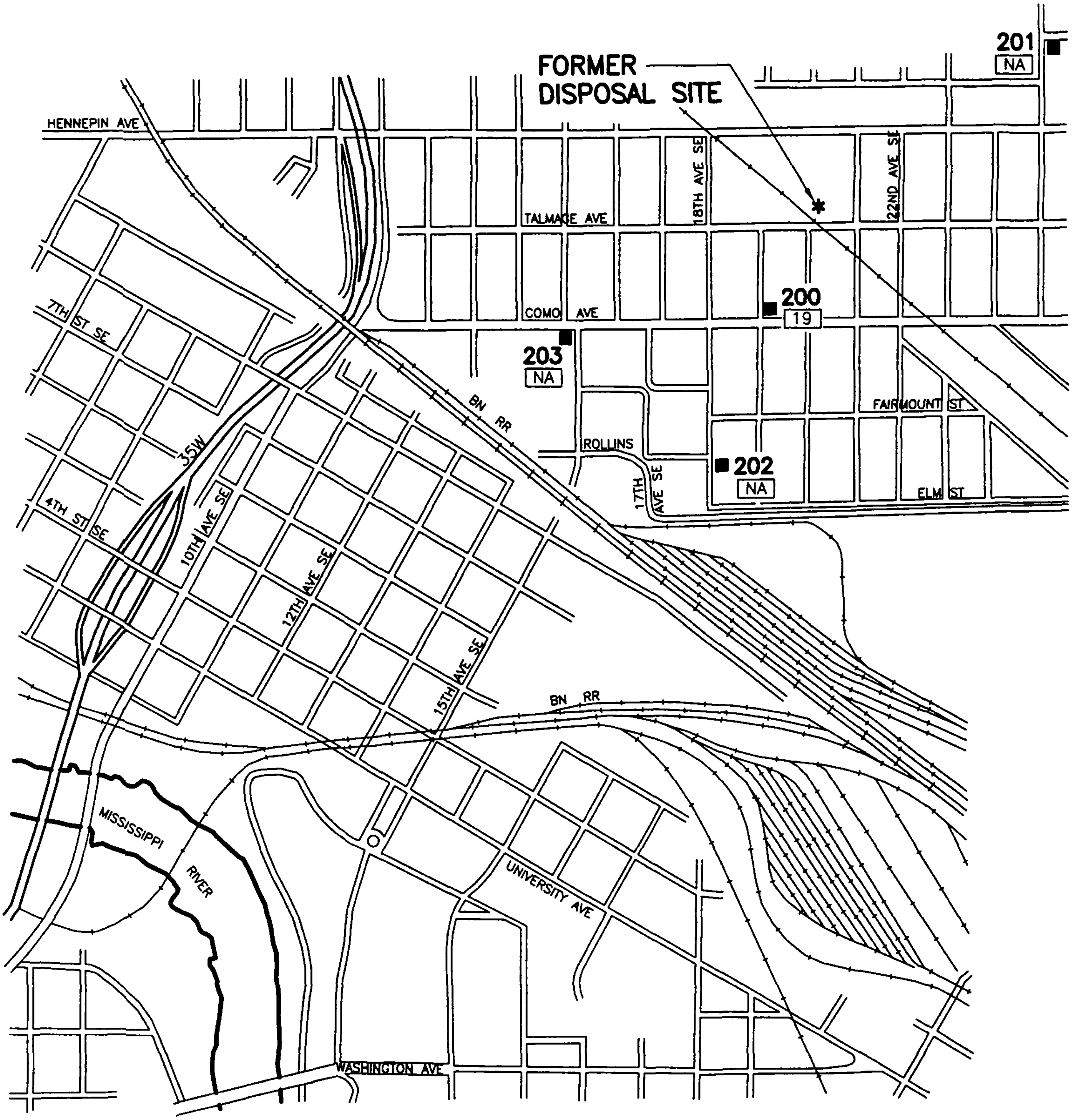
[ND] NOT DETECTED

0 1000
SCALE IN FEET

Jan Moss C:\PROJECTS\2327169\SPWQ593 1.00 01/24/1994 12:54:47

Figure 30

ST. PETER SANDSTONE
WATER QUALITY (VOC)
MAY 1993



■ ST. PETER SANDSTONE MONITORING WELL

[19] TRICHLOROETHENE CONCENTRATION (TCE) (ug/L)

[NA] NOT ANALYZED

N

0 1000
SCALE IN FEET

Figure 31

ST. PETER SANDSTONE
WATER QUALITY (TCE)
NOVEMBER 1993

Trichloroethene vs. Time

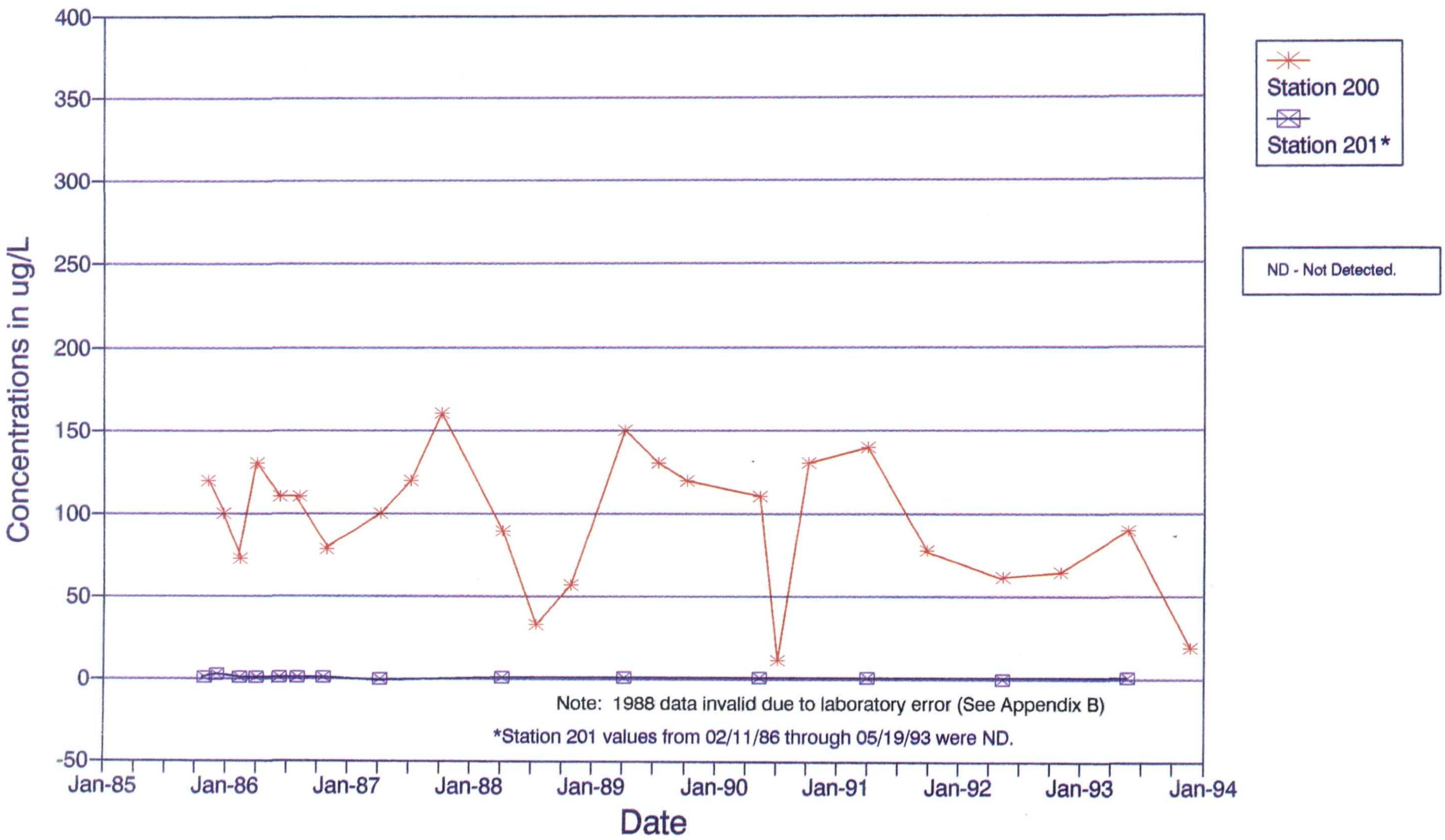


FIGURE 32

ST. PETER SANDSTONE WELLS
TCE CONCENTRATIONS
1985-1993

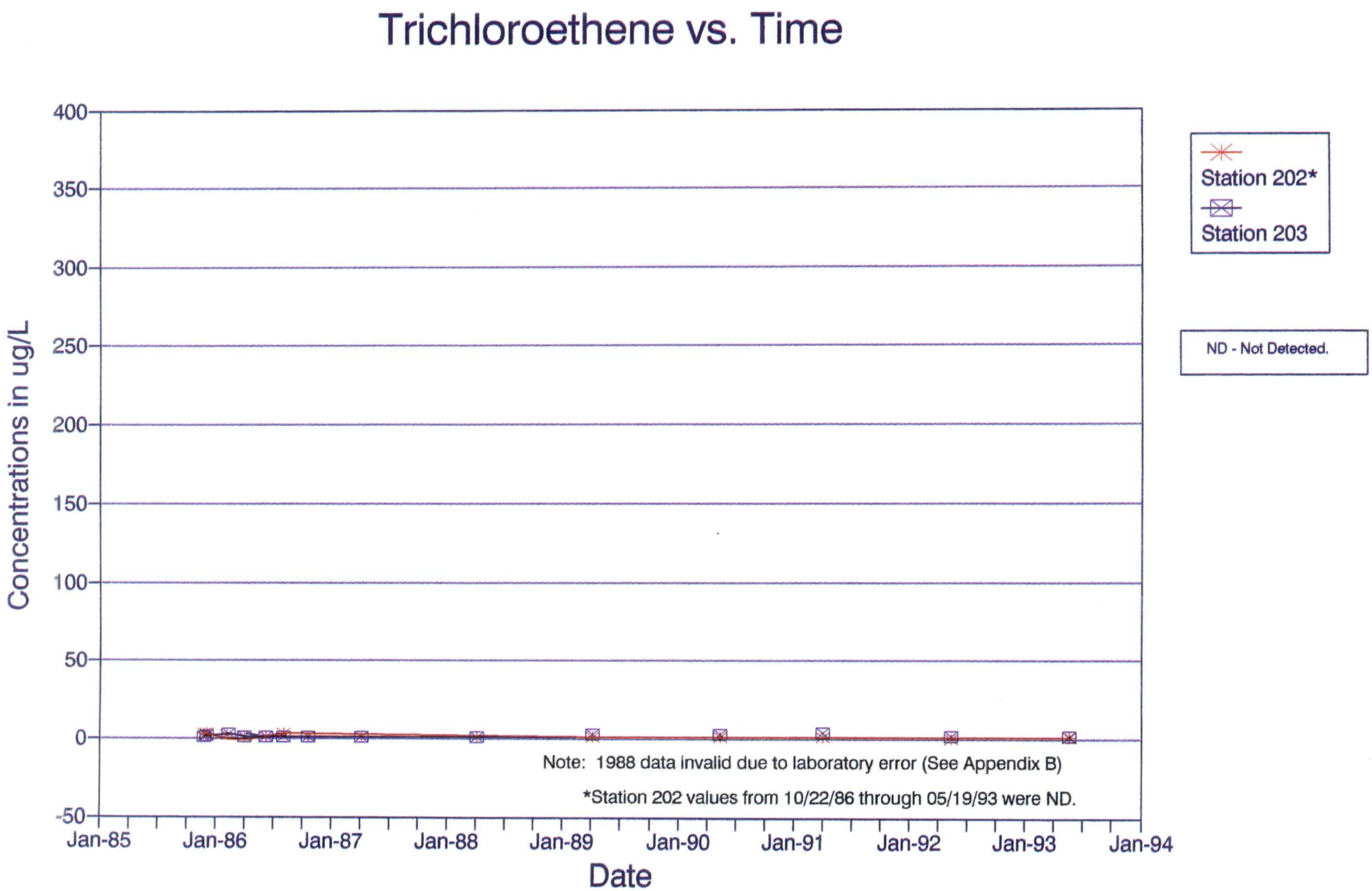


FIGURE 32 (cont.)
ST. PETER SANDSTONE WELLS
TCE CONCENTRATIONS
1985-1993

Trichloroethene vs. Time

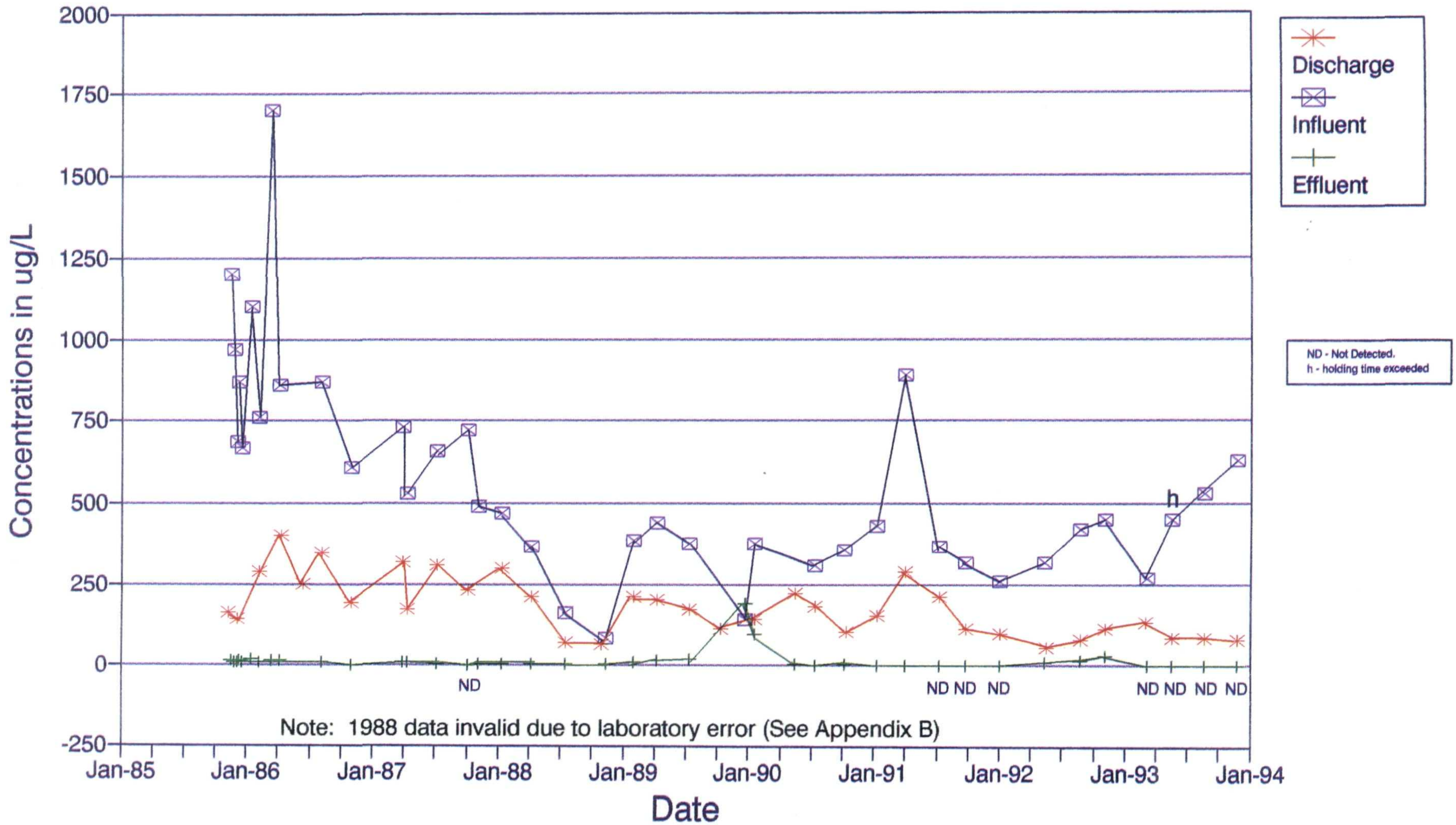


FIGURE 33
DOWNGRADIENT PUMP-OUT SYSTEM DISCHARGE
(111,112,113) AND GOUNDWATER TREATMENT
SYSTEM INFLUENT/EFFLUENT (108,109,110)*
TCE CONCENTRATIONS
1985-1993
* Well 108 removed from system, September 23, 1992

Appendices

Appendix A

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL AND VALIDATION

Table of Contents

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EXTERNAL QUALITY CONTROL	A-2

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TABLE A-2 1993 Blind Duplicate Data

APPENDIX A

QUALITY ASSURANCE/QUALITY CONTROL AND VALIDATION

INTRODUCTION

A review of quality control data was conducted to assess the integrity of the sampling procedures and analytical results for samples collected from January through November 1993. The quality control data included analytical results from samples collected to determine both internal and external quality control. Internal quality control included initial and ongoing programs of quality assurance performed by CH_2M Hill Quality Analytical Laboratory (CH_2M Hill) in accordance with their laboratory Quality Assurance/Quality Control Plan. External quality control samples involved the collection and analysis of field blank samples and masked duplicate samples.

CH_2M Hill analyzed the 1993 water samples for volatile organic compounds (VOCs) according to EPA Methods 601/602 and priority pollutant VOCs with tentatively identified compounds according to EPA Method 624.

The Minnesota Department of Health (MDH) requires that laboratories conducting analytical tests for wastewater parameters (including VOCs) be certified by the MDH. CH_2M Hill is a certified environmental laboratory in the state of Minnesota with Laboratory ID No. 001-99-250.

INTERNAL QUALITY CONTROL

Intra-laboratory quality control procedures were conducted on an on-going basis to determine the acceptability of the analytical results. Internal quality control procedures followed in the analysis of samples for volatile organic compounds included: spiking 10 percent of the samples with reference standards and calculating the percenter recovery; analyzing 10 percent of the samples in duplicate; and analyzing daily laboratory blanks to check for system contamination.

Accuracy of the analytical data was assessed by evaluating percent recovery in spiked samples. CH_2M Hill uses statistical control procedures to establish and track data accuracy. Quality control data generated during the analysis of samples demonstrated acceptable accuracy.

Data precision was assessed by evaluating laboratory duplicate analyses or duplicate spike samples analyses. A duplicate analysis is a replicate of separate aliquot of the sample or spiked sample which has been taken through the same preparation procedures as the original sample. The relative percent difference (RPD) was computed for each duplicate set of results. Quality control data generated during the analysis of samples demonstrated acceptable precision.

Laboratory deionized water blanks were analyzed periodically throughout the analysis of samples. Laboratory blanks are used to evaluate possible system contamination.

Methylene chloride and acetone were detected in one of the laboratory blanks and the trip blank associated with the priority pollutant analysis for May 1993 (Table 14). The laboratory qualified the laboratory blank results with a "j" indicating that these concentrations were estimates because the concentrations are less than the laboratory reporting limits. U.S. Environmental Protection Agency guidance (Laboratory Data Validation Functional Guidelines for Evaluating Organic Analysis, February 1988) for the evaluation of organic analysis data specified that in cases where common laboratory contaminants (such as methylene chloride and acetone) are detected, the data must be qualified when the sample concentration is less than 10 times the blank concentration. The sample data associated with this laboratory blank is qualified with a "b" qualifier, indicating the reported sample concentration is a potential false positive value based on blank data validation procedures. The laboratory blank values associated with all other 1993 data were reported as not detected.

EXTERNAL QUALITY CONTROL

External quality control procedures were used to assess laboratory precision and accuracy and the effect of sample bottle preparation and handling processes on the quality of the analytical results. Procedures included the analysis of field blanks for detection of contamination introduced during sample collection, and masked duplicate samples as a check on the reproducibility of the analytical results.

Two field blanks and four trip blanks were collected and analyzed for volatile organic compounds. The results are presented in Table A-1. No compounds were detected in the field blanks or trip blanks collected for volatile organic analysis during 1993.

Seven samples were collected in duplicate and the results of the analyses are shown in Table A-2. The precision of the masked duplicate samples were evaluated by computing the RPD for each volatile organic compound. The RPD for each duplicate pair are summarized in Table A-2. The RPD values are considered acceptable and reflective of normal sample constituent variability.

The initial trichloroethylene concentration of the influent sample for May 1993 (Table 13) fell outside the instrument linear calibration range. Therefore, the sample was diluted and reanalyzed to quantitate the trichloroethylene. The diluted analysis was performed outside EPA Recommended Holding Times and is footnoted accordingly. All other parameters were analyzed within holding times.

TABLE A-1

1993 BLANK SAMPLE DATA

(concentrations in ug/L)

	LAB BLANKS							
	03/02/93	03/02/93	03/08/93	03/08/93	05/18/93	05/19/93	05/19/93	05/19/93
1,1-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
1,2-Dichloroethylene, cis	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.5
1,2-Dichloroethylene, trans	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.5
1,2-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
Tetrachloroethylene	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
1,1,1-Trichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
Trichloroethylene	<0.50	<0.50	<0.50	<0.50	<0.50	<5	<5	<0.5
Benzene	--	--	--	--	--	<5	<5	<0.5
Toluene	--	--	--	--	--	<5	<5	<0.5
Xylenes	--	--	--	--	--	<5	<5	<0.5

	LAB BLANKS							
	05/19/93	06/08/93	06/08/93	08/23/93	08/23/93	11/22/93	11/23/93	11/23/93
1,1-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
1,2-Dichloroethylene, cis	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
1,2-Dichloroethylene, trans	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
1,2-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
Tetrachloroethylene	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
1,1,1-Trichloroethane	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	<0.50
Trichloroethylene	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Benzene	--	--	--	--	--	--	--	<0.50
Toluene	--	--	--	--	--	--	--	<0.50
Xylenes	--	--	--	--	--	--	--	<0.50

	LAB BLANKS		TRIP BLANKS				FIELD BLANKS	
	11/23/93	11/23/93	03/02/93	03/08/93	05/19/93	11/23/93	05/18/93	11/23/93
1,1-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<5	--	<0.50	--
1,2-Dichloroethylene, cis	<0.50	<0.50	<0.50	<0.50	--	--	<0.50	--
1,2-Dichloroethylene, trans	<0.50	<0.50	<0.50	<0.50	--	--	<0.50	--
1,2-Dichloroethane	<0.50	<0.50	<0.50	<0.50	<5	--	<0.50	--
1,1,2,2-Tetrachloroethane	<0.50	<0.50	<0.50	<0.50	<5	--	<0.50	--
Tetrachloroethylene	<0.50	<0.50	<0.50	<0.50	<5	--	<0.50	--
1,1,1-Trichloroethane	<0.50	<0.50	<0.50	<0.50	<5	--	<0.50	--
Trichloroethylene	<0.50	<0.50	<0.50	<0.50	<5	<0.50	<0.50	<0.50
Benzene	<0.50	<0.50	--	--	<5	--	--	--
Toluene	<0.50	<0.50	--	--	<5	--	--	--
Xylenes	<0.50	<0.50	--	--	<5	--	--	--

-- Not analyzed.

3,.014
12/22/93

TABLE A-2

1993 BLIND DUPLICATE DATA

(concentrations in ug/L)

	SS		RPD	10		RPD
	05/18/93 Sample	05/18/93 Duplicate		05/19/93 Sample	05/19/93 Duplicate	
1,1-Dichloroethane	3.2	4.5	34	<0.50	<0.50	0
1,2-Dichloroethylene, cis	1.2	2.0	50	<0.50	<0.50	0
1,2-Dichloroethylene, trans	<0.50	<0.50	0	<0.50	<0.50	0
1,2-Dichloroethane	<0.50	<0.50	0	<0.50	<0.50	0
1,1,2,2-Tetrachloroethane	<0.50	<0.50	0	<0.50	<0.50	0
Tetrachloroethylene	<0.50	<0.50	0	<0.50	<0.50	0
1,1,1-Trichloroethane	<0.50	<0.50	0	<0.50	<0.50	0
Trichloroethylene	2.5	4.3	58	46	48	5
Benzene	--	--		--	--	
Toluene	--	--		--	--	
Xylenes	--	--		--	--	
Sum Volatile Organics	6.9	11		46	48	

	INFLUENT		RPD	MG EFFLUENT		RPD
	05/19/93 Sample	05/19/93 Duplicate		05/19/93 Sample	05/19/93 Duplicate	
1,1-Dichloroethane	1.6	4 j	86	<0.50	<0.50	0
1,2-Dichloroethylene, cis	47	--		1.2	1.1	8
1,2-Dichloroethylene, trans	<0.50	--		<0.50	<0.50	0
1,2-Dichloroethane	<0.50	<5	0	<0.50	<0.50	0
1,1,2,2-Tetrachloroethane	1.9	1 j	62	<0.50	<0.50	0
Tetrachloroethylene	2.7	7	89	<0.50	<0.50	0
1,1,1-Trichloroethane	1.0	2 j	67	<0.50	<0.50	0
Trichloroethylene	450 h	520	15	22	22	0
Benzene	6.3	10	46	<0.50	<0.50	0
Toluene	23	30	27	<0.50	<0.50	0
Xylenes	5.3	10	62	<0.50	<0.50	0
Sum Volatile Organics	540	670		23	23	

-- Not analyzed.
j Reported value is less than the stated laboratory quantitation limit and is considered an estimated value.
h EPA sample extraction or analysis holding time was exceeded.

3,.015
12/22/93

TABLE A-2 (cont.)

1993 BLIND DUPLICATE DATE

(concentrations in ug/L)

	MG EFFLUENT		RPD	S		RPD
	08/23/93 Sample	08/23/93 Duplicate		11/23/93 Sample	11/23/93 Duplicate	
1,1-Dichloroethane	<0.50	<0.50	0	--	--	
1,2-Dichloroethylene, cis	1.5	1.3	14	--	--	
1,2-Dichloroethylene, trans	<0.50	<0.50	0	--	--	
1,2-Dichloroethane	<0.50	<0.50	0	--	--	
1,1,2,2-Tetrachloroethane	<0.50	<0.50	0	--	--	
Tetrachloroethylene	<0.50	<0.50	0	--	--	
1,1,1-Trichloroethane	<0.50	<0.50	0	--	--	
Trichloroethylene	33	25	27	400	270	38
Benzene	--	--		--	--	
Toluene	--	--		--	--	
Xylenes	--	--		--	--	
Sum Volatile Organics	34	26		400	270	

	ZZ		RPD
	11/23/93 Sample	11/23/93 Duplicate	
1,1-Dichloroethane	--	--	
1,2-Dichloroethylene, cis	--	--	
1,2-Dichloroethylene, trans	--	--	
1,2-Dichloroethane	--	--	
1,1,2,2-Tetrachloroethane	--	--	
Tetrachloroethylene	--	--	
1,1,1-Trichloroethane	--	--	
Trichloroethylene	70	62	12
Benzene	--	--	
Toluene	--	--	
Xylenes	--	--	
Sum Volatile Organics	70	62	

-- Not analyzed.
j Reported value is less than the stated laboratory quantitation limit and is considered an estimated value.
h EPA sample extraction or analysis holding time was exceeded.

3,.015
12/22/93

Appendix B

APPENDIX B

HISTORICAL WATER ELEVATION AND WATER QUALITY DATA

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TABLE B-1	Historical Water Elevation Data, Glacial Drift Wells
TABLE B-2	Historical Water Elevation Data, Carimona Member Wells
TABLE B-3	Historical Water Elevation Data, Magnolia Member Wells
TABLE B-4	Historical Water Elevation Data, St. Peter Sandstone Wells
TABLE B-5	Historical Water Elevation Data, Glacial Drift Pump-Out Wells
TABLE B-6	Historical Water Quality Data, Glacial Drift Wells, Trichloroethene
TABLE B-7	Historical Water Quality Data, Carimona Member Wells, Trichloroethene
TABLE B-8	Historical Water Quality Data, Magnolia Member Wells, Trichloroethene
TABLE B-9	Historical Water Quality Data, St. Peter Sandstone Wells, Trichloroethene
TABLE B-10	Historical Water Quality Data, Prairie du Chien/Jordan Well, Trichloroethene
TABLE B-11	Historical Water Quality Data, Site Pump-Out and Treatment System, Downgradient Pump-Out System, Trichloroethene

TABLE B-1

HISTORICAL WATER ELEVATION DATA
GLACIAL DRIFT WELLS

(elevations in feet/MSL)

DATE	1	3	4	106	107
02/82	843.19	--	--	--	--
02/82	842.37	--	--	--	--
03/82	842.37	--	--	--	--
03/82	842.28	--	--	--	--
03/82	842.29	835.95	833.20	--	--
04/82	842.54	836.07	833.30	--	--
04/82	842.54	836.07	833.35	--	--
11/82	843.70	836.48	833.89	--	--
02/83	842.96	836.16	833.53	--	--
04/83	843.44	836.88	834.11	840.25	840.19
06/83	842.90	837.58	834.88	839.40	839.25
09/83	--	836.95	834.38	838.80	838.68
11/83	--	--	--	838.57	--
01/84	--	--	--	839.40	837.36
01/84	--	--	--	838.48	838.41
03/84	--	837.23	834.20	838.68	838.65
10/85	842.68	836.57	--	838.52	838.42
12/85	842.38	835.19	833.40	837.12	836.96
07/87	842.0	832.75	--	--	--
10/87	842.34	834.30	--	--	--
04/88	841.90	832.89	830.23	835.63	835.54
07/88	841.69	832.45	--	--	--
10/88	841.77	833.00	--	--	--
04/89	841.74	833.30	830.79	--	835.34
07/89	841.75	833.76	--	--	--
10/89	841.72	833.98	--	--	--
05/90	--	833.65	830.43	--	--
07/90	841.90	834.35	--	836.36	836.17
10/90	841.69	834.15	--	--	--
04/91	841.36	832.92	--	--	--
09/91	842.02	834.25	--	--	--
05/92	841.96	834.19	--	--	--
11/92	841.98	834.02	--	--	--
05/93	842.00	833.85	--	--	--
11/93	842.17	834.07	--	--	--

-- Not measured.

2,.012

TABLE B-1 (cont.)

HISTORICAL WATER ELEVATION DATA
GLACIAL DRIFT WELLS

(elevations in feet/MSL)

DATE	B	Q	R	S	T
10/81	843.31	--	--	--	--
02/82	844.45	--	--	--	--
02/82	842.78	--	--	--	--
02/82	842.77	--	--	--	--
03/82	842.84	--	--	--	--
03/82	842.72	--	--	--	--
03/82	842.68	--	--	--	--
03/82	824.89	--	--	--	--
04/82	842.96	--	--	--	--
04/82	843.03	--	--	--	--
04/82	843.03	--	--	--	--
04/82	843.14	--	--	--	--
11/82	843.56	--	--	--	--
12/82	843.59	--	--	--	--
02/83	843.30	--	--	--	--
04/83	844.13	--	--	--	--
06/83	844.37	--	--	--	--
09/83	844.14	--	--	--	--
11/83	844.01	--	--	--	--
01/84	843.93	--	--	--	--
02/84	--	830.49	827.64	829.85	832.38
03/84	844.13	832.08	829.15	831.21	833.89
10/85	843.89	831.58	829.00	832.00	833.96
12/85	843.86	831.22	828.73	830.95	833.37
07/87	--	--	DRY	824.91	831.74
10/87	--	--	--	826.36	832.72
04/88	843.38	826.86	--	824.94	831.80
07/88	--	826.46	DRY	824.63	832.44
10/88	--	826.77	DRY	824.92	833.03
04/89	843.17	827.45	DRY	825.23	832.25
07/89	--	827.95	DRY	825.55	832.41
10/89	--	828.26	DRY	826.45	832.23
05/90	--	827.08	DRY	825.92	832.14
07/90	844.33	828.50	DRY	827.38	832.89
10/90	--	828.28	DRY	827.43	832.62
04/91	842.76	827.43	--	825.96	832.14
09/91	843.46	828.90	--	828.42	833.06
05/92	843.40	828.80	--	828.55	833.05
11/92	843.43	828.88	--	828.09	832.61
05/93	843.47	828.18	--	827.04	832.56
11/93	843.64	828.42	DRY	828.07	833.74

-- · Not measured.

2,.012

TABLE B-1 (cont.)

HISTORICAL WATER ELEVATION DATA
GLACIAL DRIFT WELLS

(elevations in feet/MSL)

DATE	U	V	W	X
02/84	837.07	--	--	--
03/84	838.82	818.16	818.25	829.00
10/85	838.11	818.61	818.49	831.59
12/85	837.30	817.99	817.96	829.02
07/87	--	815.3	814.4	DRY
10/87	--	815.93	816.10	--
04/88	835.58	814.51	814.59	DRY
07/88	--	814.03	814.03	DRY
10/88	--	814.44	814.54	DRY
04/89	835.72	814.19	814.34	DRY
07/89	--	814.77	814.86	822.05
10/89	--	815.16	815.26	DRY
05/90	835.86	814.64	814.38	822.07
07/90	--	816.65	816.75	822.95
10/90	--	816.70	816.80	823.08
04/91	835.35	815.60	815.69	DRY
09/91	836.54	818.19	818.18	824.25
05/92	836.50	817.77	817.81	823.41
11/92	836.21	817.27	817.44	824.05
05/93	836.22	816.13	816.29	822.55
11/93	836.42	817.17	817.23	823.81

-- Not measured.

2.,012

TABLE B-2

HISTORICAL WATER ELEVATION DATA
CARIMONA MEMBER WELLS

(elevations in feet/MSL)

DATE	8	9	10	11	12	13
11/82	828.91	--	--	--	--	--
04/83	836.76	--	--	--	--	--
06/83	835.81	--	--	--	--	--
09/83	838.68	--	--	--	--	--
09/83	835.51	--	--	--	--	--
03/84	830.15	830.15	830.21	830.18	831.43	830.21
10/85	830.58	830.61	830.62	830.65	832.11	830.01
12/85	829.71	830.05	829.86	829.73	831.50	829.25
07/87	827.10	827.3	827.28	827.26	827.83	826.49
10/87	828.79	828.69	828.72	828.79	828.63	828.14
04/88	827.71	827.85	827.86	827.74	828.12	827.05
07/88	824.91	825.12	825.07	824.97	825.40	824.36
10/88	826.83	826.98	826.99	826.86	826.61	826.17
04/89	827.13	827.37	827.37	827.16	827.20	826.63
07/89	825.41	825.64	825.59	825.43	826.18	824.74
10/89	827.32	827.52	827.82	827.37	826.70	826.78
05/90	827.06	827.38	827.26	827.31	827.52	826.65
07/90	827.92	828.18	828.10	827.84	826.73	827.20
10/90	828.38	828.59	828.58	828.41	828.23	827.78
04/91	828.63	828.84	828.83	828.70	828.92	828.06
09/91	829.19	829.40	829.40	829.15	828.46	828.55
05/92	828.87	829.02	829.01	828.93	829.26	828.29
11/92	828.81	828.98	829.03	828.85	827.60	828.23
05/93	827.37	827.38	827.58	827.39	826.95	826.72
11/93	829.26	829.34	829.45	829.56	828.36	828.89

-- Not measured.

2,.011

TABLE B-2 (cont.)

HISTORICAL WATER ELEVATION DATA
CARIMONA MEMBER WELLS

(elevations in feet/MSL)

DATE	108 (1)	BB	RR	SS	UU	WW
10/81	--	828.09	--	--	--	--
11/81	--	827.85	--	--	--	--
02/82	--	829.87	--	--	--	--
02/82	--	827.85	--	--	--	--
02/82	--	827.77	--	--	--	--
03/82	--	827.85	--	--	--	--
03/82	--	828.61	--	--	--	--
03/82	--	827.81	827.73	--	--	--
03/82	--	827.76	827.73	--	--	--
04/82	--	827.89	827.76	--	--	--
04/82	--	827.82	--	--	--	--
04/82	--	827.82	827.57	--	--	--
04/82	--	828.08	828.17	--	--	--
11/82	--	829.07	829.12	835.43	828.85	828.91
12/82	--	829.18	829.22	835.67	831.10	829.08
02/83	--	828.89	828.98	834.07	828.98	828.76
02/83	--	--	--	834.25	--	--
04/83	--	829.69	829.72	834.13	829.54	829.48
06/83	--	829.96	829.97	834.29	829.86	829.77
09/83	--	829.66	829.53	823.15	829.55	829.45
11/83	830.12	830.15	830.08	833.90	830.24	829.95
01/84	--	829.84	--	833.55	829.80	829.69
01/84	830.65	830.12	828.99	833.50	830.02	829.94
03/84	830.92	830.25	830.16	832.34	830.18	830.08
10/85	830.77	830.26	830.19	831.76	830.63	830.60
12/85	812.90	829.76	829.90	830.59	829.88	829.79
07/87	805.9	--	827.11	826.18	--	--
10/87	806.06	--	828.82	827.27	--	--
04/88	804.57	827.81	827.85	826.22	827.72	827.71
07/88	804.45	--	825.11	824.05	--	--
10/88	804.49	--	826.95	825.37	--	--
04/89	807.81	827.34	827.35	825.54	827.31	827.31
07/89	804.51	--	825.65	823.62	--	--
10/89	827.49	--	827.57	825.12	--	--
05/90	--	--	827.41	824.77	827.28	827.27
07/90	804.54	828.01	827.98	827.05	--	--
10/90	804.64	--	828.48	826.74	--	--
04/91	807.87	828.75	828.76	826.42	828.69	828.66
09/91	804.55	829.25	829.41	826.95	829.23	831.23
01/92	830.22	--	--	--	--	--
05/92	805.36	828.93	829.08	826.42	828.92	828.89
11/92	829.22	828.65	829.01	824.50	828.93	828.86
05/93	--	827.16	827.48	822.62	827.40	827.04
11/93	829.53	829.29	829.63	823.68	829.50	829.50

(1) Carimona pump-out well.
-- Not measured.

2,.011

TABLE B-3

HISTORICAL WATER ELEVATION DATA
MAGNOLIA MEMBER WELLS

(elevations in feet/MSL)

DATE	OO	QQ	TT	VV	ZZ	MG1 (1)	MG2 (1)
03/82	823.60	823.25	--	--	--	--	--
03/82	823.60	823.34	--	--	--	--	--
03/82	823.48	823.29	--	--	--	--	--
04/82	823.64	823.37	--	--	--	--	--
04/82	823.72	823.42	--	--	--	--	--
04/82	823.99	823.75	--	--	--	--	--
11/82	824.96	824.61	822.41	825.57	--	--	--
12/82	824.79	824.41	822.59	825.76	--	--	--
02/83	825.51	823.57	822.34	825.50	--	--	--
02/83	--	--	822.62	--	--	--	--
04/83	825.29	823.00	822.90	826.32	--	--	--
06/83	825.80	825.61	823.60	826.43	--	--	--
09/83	824.71	825.20	829.55	826.18	--	--	--
11/83	825.69	825.44	823.44	826.52	--	--	--
01/84	825.46	--	823.26	826.32	--	--	--
03/84	825.78	825.61	823.54	826.64	830.2	--	--
02/85	--	--	822.62	--	--	--	--
10/85	825.76	825.46	823.26	826.99	830.67	--	--
12/85	825.57	825.39	822.74	826.24	830.65	--	--
02/86	824.74	824.49	822.10	825.60	830.05	--	--
04/86	824.75	824.52	822.10	825.60	829.65	--	--
06/86	824.89	824.68	822.31	825.66	828.31	--	--
08/86	824.86	824.71	822.32	825.65	829.44	--	--
10/86	825.49	825.24	822.90	826.33	830.45	--	--
04/87	823.87	823.66	821.46	824.83	829.25	--	--
07/87	822.85	822.53	820.42	823.42	827.93	--	--
10/87	824.24	823.96	821.77	824.99	829.98	--	--
04/88	823.31	823.03	820.91	824.14	828.44	--	--
07/88	821.14	820.82	818.88	821.73	825.73	--	--
10/88	822.46	822.11	820.13	823.34	827.57	--	--
04/89	822.82	822.47	820.46	823.75	828.72	--	--
07/89	821.66	821.32	819.38	822.36	826.05	--	--
10/89	823.07	822.70	820.69	823.98	828.20	--	--
05/90	822.79	822.51	820.42	823.65	828.04	--	--
07/90	823.67	823.36	821.35	824.57	828.65	--	--
10/90	823.99	823.73	821.56	824.88	829.16	--	--
04/91	824.52	824.25	821.75	825.46	829.44	--	--
09/91	825.50	825.19	823.05	826.28	829.94	--	--
05/92	825.10	824.83	822.63	825.87	829.66	824.59	823.38
11/92	820.27	820.33	817.29	822.01	829.61	811.91	812.52
05/93	820.42	818.46	815.64	820.33	828.12	--	--
11/93	820.28	820.31	817.42	822.23	830.26	--	--

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(1) Magnolia Pump-out well

-- Not measured.

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2,.010

TABLE B-4

HISTORICAL WATER ELEVATION DATA
ST. PETER SANDSTONE WELLS

(elevations in feet/MSL)

DATE	200	201	202	203
10/85	--	779.64	751.98	752.05
12/85	758.68	780.24	752.60	757.58
07/87	760.63	777.82	753.86	753.43
10/87	760.47	779.35	753.28	753.42
04/88	761.89	780.40	753.36	753.37
07/88	758.57	773.59	752.28	752.10
10/88	760.78	778.42	752.53	752.43
04/89	762.22	779.61	753.67	753.57
07/89	758.96	775.98	752.77	752.37
10/89	760.36	777.25	752.70	752.43
05/90	761.79	778.59	753.72	753.29
07/90	759.54	776.15	753.16	752.61
10/90	759.90	776.67	752.44	751.93
04/91	761.75	778.01	753.50	752.94
09/91	761.38	778.26	753.38	752.96
05/92	762.57	778.37	754.73	754.01
11/92	763.44	780.11	754.93	754.23
05/93	763.12	778.52	754.94	754.05
11/93	764.00	780.11	754.86	753.79

-- Not measured.

2,.013

TABLE B-5

HISTORICAL WATER ELEVATION DATA
GLACIAL DRIFT PUMP-OUT WELLS

(elevations in feet/MSL)

DATE	109 (1)	110 (1)	111 (2)	112 (2)	113 (2)
10/85	837.21	835.62	829.25	829.10	829.20
12/85	828.19	829.11	828.83	828.59	828.77
07/87	831.26	829.63	816.75	811.67	814.24
10/87	829.94	828.98	813.70	814.64	815.68
04/88	828.90	823.37	808.70	811.81	813.00
07/88	831.00	822.35	815.35	807.91	812.63
10/88	829.99	829.52	815.62	811.68	813.15
04/89	831.41	828.90	818.43	811.80	817.22
05/90	--	830.71	818.20	807.67	817.96
07/90	827.27	831.02	819.07	811.77	818.80
10/90	829.63	831.51	819.23	811.03	819.12
04/91	826.58	826.60	817.98	808.26	817.91
09/91	830.56	829.33	820.19	--	820.27
01/92	826.56	828.73	819.50	812.12	819.42
05/92	827.20	829.41	819.34	812.17	820.21
11/92	827.67	830.60	820.15	815.62	820.43
05/93	827.24	829.56	818.46	807.05	818.74
11/93	828.06	830.81	819.26	810.43	819.83

-- Not measured due to restricted site access.
(1) Site glacial drift pump-out wells.
(2) Down-gradient glacial drift pump-out wells.

2,.012

TABLE B-6

HISTORICAL WATER QUALITY DATA
GLACIAL DRIFT WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	B	Q	R	S	T
04/82	6.0	--	--	--	--
12/82	1100	--	--	--	--
12/83	780	--	--	--	--
02/84	--	<1.3	670	770	<1.3
10/85	1200	20	1100	740	<0.3
12/85	1100	14	820	750	<0.8
02/86	1300	11	31	650	<0.5
04/86	1000	13	DRY	1100	<0.2
06/86	1100	4.7	160	930	<0.2
08/86	1000	5.6	DRY	880	<0.2
10/86	--	3.2	--	620	<0.2
11/86	830	--	--	--	--
04/87	800	2.6	DRY	650	<0.2
07/87	--	--	DRY	740	--
10/87	--	--	--	1000	--
04/88*	330	0.86	DRY	460	<0.50
07/88*	--	--	DRY	160	--
10/88*	--	--	DRY	110	--
04/89	250	1.1	DRY	860	<0.5
07/89	--	--	DRY	620	--
10/89	--	--	DRY	630	--
05/90	--	0.7	DRY	710	<0.5
07/90	330	--	DRY	200	--
10/90	--	--	DRY	770	--
04/91	340	0.7	--	870	<0.5
09/91	--	--	--	480	--
05/92	510	<1.0	--	510	<1.0
11/92	--	--	--	770	--
05/93	580	<0.50	--	390	<0.50
11/93	--	--	--	400	--

-- Not analyzed.

* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.014

TABLE B-6 (cont.)

HISTORICAL WATER QUALITY DATA
GLACIAL DRIFT WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	1	3	4
04/82	6.0	780	4.5
12/83	27	800	380
10/85	1.4	1100	--
11/85	--	--	440
12/85	1.5	770	440
02/86	1.4 s	680	200
04/86	3.1	1200	210
06/86	8.1	1300	180
08/86	9.3	890	280
10/86	0.9	720	200
04/87	2.7	740	120
07/87	0.4	770	--
10/87	0.8	960	--
04/88*	<0.50	440	55
07/88*	0.5	140	--
10/88*	<0.50	98	--
04/89	0.8	320	55
07/89	0.6 s	340	--
10/89	0.5	530	--
05/90	--	520	77
07/90	0.8	770	--
10/90	<0.5	310	--
04/91	3.1	1500	--
09/91	1.3	300	--
05/92	2.2	400	--
11/92	0.5	170	--
05/93	<0.50	470	--
11/93	<0.50	740	--

-- Not analyzed.

s Potential false positive value based on data validation procedures.

* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.016

TABLE B-6 (cont.)

HISTORICAL WATER QUALITY DATA
GLACIAL DRIFT WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	U	V	W	X
02/84	<1.3	--	--	--
03/84	--	78	7.5	2.2
10/85	2.6	220	8.1	2.1
12/85	3.9	140	32	5.0
02/86	2.9	180	14	0.9 s
04/86	3.2	170	18	0.9
06/86	1.6	97	10	0.9
08/86	16	130	18	0.7
10/86	1.4	92	6.2	0.5
04/87	2.7	160	24	--
07/87	--	180	42	--
10/87	--	140	56	--
04/88*	--	160	43	DRY
07/88*	--	33	8.1	--
10/88*	--	37	26	--
04/89	--	130	57	DRY
07/89	--	120	22	--
10/89	--	120	25	--
05/90	--	110	31	DRY
07/90	--	120	<0.5	--
10/90	--	110	11	--
04/91	2.0	130	40	--
09/91	--	73	20	--
05/92	<1.0	63	5.9	<1.0
11/92	--	83	1.3	--
05/93	0.7	68	2.9	<0.50
11/93	--	100	2.9	--

-- Not analyzed.
s Potential false positive value based on data validation procedures.
* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.
2.015

TABLE B-7

HISTORICAL WATER QUALITY DATA
CARIMONA MEMBER WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	BB	RR	SS	UU	WW
05/82	--	46	--	--	--
06/82	1600	--	--	--	--
12/82	1600	43	<0.05	78	2100
12/83	1400	33	<1.5	81	1700
10/85	1900	110	0.4 s	150	2300
12/85	1100	95	1.2	79	1200
02/86	1300	88	<0.5	71	740
04/86	2200	170	0.4	81	540
06/86	2100	85	0.3	37	290
08/86	1800	100	0.3	45	220
10/86	--	--	<0.2	36	--
11/86	1300	100	--	--	290
04/87	1100	110	1.2	12	290
04/88*	530*	220	<0.50	23	320
04/89	340	180	1.3	38	530
05/90	--	60	4.1	35	450
07/90	530	--	--	--	--
04/91	1100	150	4.5	64	420
09/91	--	--	--	--	--
05/92	870	90	2.2	23	700
05/93	940	93	2.5	29	130

-- Not analyzed.

s Potential false positive value based on data validation procedures.

* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.017

TABLE B-7 (cont.)

HISTORICAL WATER QUALITY DATA
CARIMONA MEMBER WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	8	9	10	11	12	13	108
04/83	820	--	--	--	--	--	--
11/83	--	--	--	--	--	--	1100
12/83	96	<0.05	2.6	120	<1.5	--	--
01/84	--	--	--	--	--	--	1100
03/84	--	--	--	--	--	25	--
10/85	2300	17	1500	2.7	--	1.9	--
11/85	--	--	--	--	<0.2	--	1500
12/85	650	10	1100	520	<0.8	21	820
02/86	240	6.7	420	250	<0.5	9.7	700
04/86	180	8.0	290	120	0.5	120	750
06/86	140	6.1	280	58	<0.2	130	640
08/86	160	6.7	270	67	0.2	14	580
10/86	110	5.4	220	40	<0.2	0.5	540
04/87	86	5.1	120	160	<0.2	140	450
07/87	--	0.6	150	25	<0.2	--	580
10/87	--	9.5	170	180	<0.5	--	560
04/88*	160	4.5	56	79	<0.5	<0.50	200
07/88*	--	1.7	34	0.3	<0.5	--	96
10/88*	--	10	58	0.7	1.0 s	--	87
04/89	380	9.8	160	110	<0.5	110	530
07/89	--	9.9	99	3.6	2.1	--	340
10/89	--	12	140	5.0	<0.5	--	--
12/89	--	--	--	--	--	--	490
05/90	100	8.5	150	<0.5	0.7	110	570
07/90	--	43	180	16	<0.5	--	400
10/90	--	9.4	130	240	<0.5	--	420
04/91	80	7.3	110	8.7	<0.5	<0.5	710
09/91	--	10	120	3.2	<0.5	--	76
05/92	47	3.2	58	190	<1.0	71	380
11/92	--	2.4	59	66	<0.5	--	--
05/93	92	1.9	46	120	<0.50	26	--
06/93	--	--	--	--	--	--	640
11/93	--	0.78	43	180	<0.50	--	300

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s Potential false positive value based on data validation procedures.

-- Not analyzed.

* The 1988 analytical data generated from Serco has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.005

TABLE B-8

HISTORICAL WATER QUALITY DATA
MAGNOLIA MEMBER WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	OO	QQ	TT	VV	ZZ
05/82	15	--	--	--	--
06/82	--	13	--	--	--
12/82	56	13	8.9	--	--
03/84	--	--	--	--	14
10/85	49	2.9	26	140	85
12/85	31	7.3	19	93	28
02/86	36	5.2	27	92	200
04/86	120	6.0	33	280	440
06/86	27	1.0	20	83	91
08/86	19	0.6	40	99	39
10/86	32	6.4	23	77	190
04/87	130	2.5	34	63	230
04/88*	160	<0.50	16	63	130
07/88*	20	--	--	9.4	--
10/88*	34	--	--	25	43
04/89	90	3.7	30	59	180
07/89	70	--	--	87	34
10/89	67	--	--	150	33
05/90	58	3.4	26	33	120
07/90	62	--	--	27	61
10/90	30	--	--	46	36
04/91	5.1	<0.5	140	75	170
09/91	5.0	--	--	48	--
05/92	3.1	--	58	60	88
06/92	--	4.7	--	--	--
11/92	17	--	6.4	29	96
05/93	11	13	0.7	190	73
11/93	5.7	--	1.8	150	70

-- Not analyzed.

* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by the independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.007

TABLE B-9

HISTORICAL WATER QUALITY DATA
ST. PETER SANDSTONE WELLS
TRICHLOROETHENE

(concentrations in ug/L)

DATE	200	201	202	203
10/85	--	0.5 s	--	--
11/85	120	--	2.6	0.5 s
12/85	100	2.9	2.0	1.2
02/86	72	<0.5	1.9	2.5
04/86	130	<0.2	0.2	0.6
06/86	110	<0.2	0.2 s	0.5
08/86	110	<0.2	2.7	0.5
10/86	78	<0.2	<0.2	0.5
04/87	100	0.1	<0.2	0.7
07/87	120	--	--	--
10/87	160	--	--	--
04/88*	89	<0.50	<0.50	<0.50
07/88*	33	--	--	--
10/88*	56	--	--	--
04/89	150	<0.5	<0.5	2.1
07/89	130	--	--	--
10/89	120	--	--	--
05/90	110	<0.5	0.8	2.8
07/90	11	--	--	--
10/90	130	--	--	--
04/91	140	<0.5	<0.5	3.0
09/91	77	--	--	--
05/92	61	<1.0	<1.0	1.2
11/92	64	--	--	--
05/93	89	<0.50	<0.50	1.4
11/93	19	--	--	--

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s Potential false positive value based on data validation procedures.

-- Not analyzed.

* The 1988 analytical data generated form Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.008

TABLE B-10

HISTORICAL WATER QUALITY DATA
PRAIRIE DU CHIEN/JORDAN WELL
TRICHLOROETHENE

(concentrations in ug/L)

DATE	HENKEL
10/85	71
12/85	44
02/86	48
04/86	OFF
06/86	OFF
08/86	54
11/86	6.9
04/87	7.1
07/87	20
10/87	6.7
04/88*	13
07/88*	1.5
10/88*	8.0
04/89	12
07/89	10
10/89	11
07/91	49
09/91	18
05/92	31
11/92	<0.5
05/93	16
11/93	36

* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988 . Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.
2,.006

TABLE B-11

HISTORICAL WATER QUALITY DATA
SITE PUMP-OUT AND TREATMENT SYSTEM
DOWNGRADIENT PUMP-OUT SYSTEM
TRICHLOROETHENE

(concentrations in ug/L)

DATE	(1) DISCHARGE	(2) INFLUENT	(3) EFFLUENT	(4) MG EFFLUENT
11/85	160	1200	13	--
12/85	140	870	12	--
01/86	--	1100	17	--
02/86	290	760	8.4	--
03/86	--	1700	14	--
04/86	400	860	11	--
06/86	250	--	--	--
08/86	350	870	6.7	--
10/86	190	610	1.0	--
03/87	320	730	6.8	--
04/87	170	530	8.3	--
07/87	310	660	2.8	--
10/87	230	720	<0.5	--
11/87	--	490	2.6	--
01/88*	300	470	4.4	--
04/88*	210	370	5.3	--
07/88*	70	160	1.2	--
10/88*	64	--	--	--
11/88*	--	84	3.7	--
01/89	210	390	9.8	--
04/89	200	440	13	--
07/89	170	380	20	--
10/89	110	--	--	--
12/89	--	140	190	--
01/90	140	380	96	--
05/90	220	370	1.2	--
07/90	180	310	0.9	--
10/90	100	360	2.9	--
01/91	150	430	0.8	--
04/91	290	890	1.0	--
07/91	210	370	<0.5	--
09/91	110	320	<0.5	--
01/92	99	260	<1.0	--
05/92	55	320	8.3	--
08/92	78	420	15	--
11/92	110	450	28	32

(1) Flow rate weighted composite sample (pump-out wells 111, 112, and 113)
(2) Flow rate weighted composite sample (pump-out wells 108, 109, and 110)
(3) Effluent from treatment system.
(4) Effluent from site pump-out wells MG1 and MG2.
-- Not analyzed.
* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.009

TABLE B-11 (cont.)

HISTORICAL WATER QUALITY DATA
SITE PUMP-OUT AND TREATMENT SYSTEM
DOWNGRADIENT PUMP-OUT SYSTEM
TRICHLOROETHENE

(concentrations in ug/L)

DATE	(1) DISCHARGE	(2) INFLUENT	(3) EFFLUENT	(4) MG EFFLUENT
03/93	130	270	<0.50	--
05/93	82	450 h	<0.50	22
08/93	83	530	<0.50	33
11/93	78	630	<0.50	24

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(1) Flow rate weighted composite sample (pump-out wells 111, 112, and 113)
(2) Flow rate weighted composite sample (pump-out wells 108, 109, and 110)
(3) Effluent from treatment system.
(4) Effluent from site pump-out wells MG1 and MG2.
-- Not analyzed.
h EPA sample extraction or analysis holding time was exceeded.
* The 1988 analytical data generated from Serco Laboratories has been determined to be unreliable due to laboratory equipment and method performance problems. This has been verified by split sample analysis by two independent laboratories during 1988. Other documentation including correspondence for Serco Laboratories justifying this decision to qualify the 1988 data exists in the project file.

2,.009

Appendix C

APPENDIX C

EAST HENNEPIN AVENUE SITE

PROPOSED 1994-1999 OPERATIONS AND MONITORING PLAN

The following monitoring plan is recommended for the period January 1, 1994 to December 31, 1999. The proposed plan is consistent with the terms of the Consent Order, and is suitable for a site with a status characterized as long term operation and monitoring.

Intensive monitoring of the East Hennepin Avenue site has occurred since February 1984. The results from this monitoring have defined the limits of groundwater contamination; have documented the effectiveness of the site groundwater pump-out systems; and have documented that site conditions in all affected aquifers have been stable since 1987.

The Consent Order specifies that the purpose of the groundwater monitoring program is to: monitor the effectiveness of the groundwater pump-out systems; define changes in the distribution of volatile hydrocarbon concentrations; and determine when operation of the system can be shut down.

The effectiveness of groundwater pump-out systems has been determined through aquifer pumping tests and groundwater modeling. The operational history (pumping rates and total gallons pumped) has been monitored since 1985. This time period includes both record wet and record dry years.

General Mills, Inc. proposes to monitor the continued effectiveness of the pump-out systems through water quality monitoring and through operational monitoring. Water quality monitoring will involve the annual collection of groundwater samples from down gradient glacial drift Wells Q, T, V, W and X. The samples will be analyzed on alternating years for trichloroethylene and List 2 volatile organic compounds (Table 1).

Operational monitoring will involve the comparison of monthly mean pumping rates with historical pumping rates. If pumping rates fall below an action level (Table 2), an assessment of the operational status of the well will be conducted and necessary repairs will be made.

Platteville Formation pump-out system operational monitoring will also include an annual 24-hour recovery test. This test will be conducted to determine if Magnolia member pump-out Wells MG-1 and MG-2 are maintaining an adequate capture zone in the Platteville Formation. The recovery test will involve the measurement of water levels in Wells RR, SS, VV, OO, TT and WW. Water levels will be measured prior to, and 24-hours after an annual shutdown of pump-out Wells MG-1 and MG-2. The data will be evaluated to determine if the Magnolia wells continue to generate similar drawdown as was observed during the 1992 pumping test.

The results of long term groundwater quality monitoring at the site indicate that site groundwater contaminant concentrations are fluctuating (since 1987) within a range of historical concentrations. Trends indicating a gradual improvement or degradation of water quality have not been observed. Future change is not anticipated because the groundwater pump-out systems are effectively containing groundwater affected by the East Hennepin Avenue site.

As indicated previously Glacial Drift Wells Q, T, V, W and X will be monitored on an annual basis for trichloroethylene (even numbered years) and List 2 volatile organic compounds (odd numbered years). Continued monitoring of Platteville Formation Wells 8, 9, 10, 12, 13, QQ, SS and TT is also proposed. Monitoring will consist of the annual collection of groundwater samples for the analysis of trichloroethylene (even numbered years) and List 2 volatile organic compounds (odd numbered years).

Monitoring of all glacial drift monitoring wells located within the capture zone of the glacial drift pump-out systems (Wells 1, B, 3, R, S and U), and monitoring of Platteville Formation Monitoring Wells 11, BB, RR, WW, VV, OO and ZZ (located within the Platteville Formation pump-out system capture zone) will be discontinued. The purpose of monitoring groundwater quality within the capture zone of the pump-out systems is to determine if the concentration of trichloroethylene has fallen below the Consent Order specified standard of 270 μg/L (glacial drift monitoring wells) or 27 μg/L (Platteville Formation monitoring wells). The concentration of trichloroethylene, however, has stabilized above this standard at many of these locations, and as a result, continued monitoring is unnecessary.

Monitoring of the St. Peter monitoring wells and the Henkel well will also be discontinued. The collection of additional data will not provide a better understanding of the water quality in these aquifers. Nine years of monitoring has adequately characterized water quality at these monitoring points and has demonstrated that the quality of groundwater is not changing.

NPDES monitoring will continue as specified in the permits. NPDES monitoring currently involves the collection of effluent water quality samples from each pump-out system and the stripper tower. In addition to trichloroethylene and List 2 volatile organic compounds, priority pollutant volatile organic compounds and flow rate measurements are required on a routine basis.

Quarterly letter reports describing the results of operations, monitoring and maintenance will be prepared and submitted to the Minnesota Pollution Control Agency. The reports will contain tables summarizing operational and monitoring data. Laboratory data reports will be attached to the report. Any data which indicates a long term change in the operational status or effectiveness of the pump-out systems will be discussed in detail. A description of any action taken in response to this information will also be documented.

TABLE 1

LIST 2 VOLATILE ORGANIC COMPOUNDS

1,1-Dichloroethane
1,2-Dichloroethane
1,2-Dichloroethylene, cis
1,2-Dichloroethylene, trans
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
1,1,1-Trichloroethane
Trichlorethylene
Benzene
Toluene
Xylenes

TABLE 2

PUMP-OUT SYSTEM OPERATION GUIDELINES

PUMPING RATES

PUMP-OUT WELL IDENTIFICATION	TARGET PUMPING RATE (AVERAGE MONTHLY GPM)	ACTION LEVEL (AVERAGE MONTHLY GPM)
WELL 109	30	20
WELL 110	50	40
WELL 111	90	80
WELL 112	100	80
WELL 113	90	80
WELL MG-1	100	80
WELL MG-2	100	80

If action levels are not met, an assessment of the operational status of the pump-out well will be undertaken and any necessary repairs will be made.

Appendix D

BARR ENGINEERING CO.

MEMORANDUM

TO: 23\27-169PZS02

FROM: Amal M.Djerrari and R.W. Wuolo

SUBJECT: Proposed Wells in Which Water Quality Monitoring Should be Discontinued

DATE: January 5, 1994

Introduction

In a letter Dated October 14, 1993 to the Minnesota Pollution Control Agency (MPCA) which included the Proposed 1994-1999 Operations and Monitoring Plan, General Mills, Inc. proposed to reduce the number of wells to be monitored as part of the pump-out systems monitoring. In response to this letter, the MPCA required that General Mills demonstrates that the wells to be removed from the monitoring program be within the system capture zone.

The following sections presents the result of pump-out system capture zone assessment and make recommendations on monitoring wells to be removed from the monitoring program.

Glacial Drift Aquifer

To evaluate which monitoring wells are within the capture zone of the glacial drift aquifer pump-out system, a simplified SLAEM model was developed. This simple model is not intended to accurately represent groundwater flow conditions prevailing in the glacial drift aquifer. Rather, conservative assumptions were built in this simplified model to provide a lower bound estimate of the capture zone. This conservative estimate of the capture zone is used to select the wells in which monitoring should be discontinued.

The simplified SLAEM model was constructed using:

- An upgradient and a downgradient linesinks with specified hydraulic heads of 860 and 810 feet MSL. respectively, to set a hydraulic gradient across the site.

- An infiltration rate of 8 inches per year.

- A conservative hydraulic conductivity of 0.1 cm/s was used . This high value of the hydraulic conductivity was selected to underestimate the width of the capture zone. Permeability coefficients of 2 x 10^{-3} to 5 x 10^{-2} cm/s were estimated based on Hazen's approximation using grain size distribution of samples from the glacial drift aquifer (Barr, 1985). The hydraulic conductivity derived from a pump test at Well 109 was estimated to be 2.4 x 10^{-3} cm/s (Barr, 1985).

- A base of 804 was assumed for the model. The top of the till considered to be the base of the aquifer actually slopes from Elevation 820 at well 1 to Elevation 804 at Well 112. Assuming the lower base for the whole aquifer increases the saturated thickness and thus underestimates the width of the capture zone.

This simplified model was approximately calibrated to yield undisturbed heads in the aquifer similar to those observed in April 1983, prior to installation of the pump-out system (Barr, 1983). This calibration was performed by varying the head specified on the upgradient linesink.

To evaluate the pump-out system capture zone, Pump-out Wells 109, 110, 111, 112, and 113 were added to the model. The wells were assumed to be pumping at their 1992 average pumping rates (i.e., 45 gpm, 46 gpm, 91 gpm, 117 gpm, and 69 gpm, respectively). SLAEM data files are provided in Attachment 1. The capture zone predicted by the model is presented in Figure 1.

The hydraulic heads predicted by the model are higher than those measured in November and May 1992 (Barr, 1993). The heads predicted by the model are up to 12 feet higher around well 112. This underestimation of the drawdowns is an indication that the permeability used in the model is, as stated above, larger than the actual hydraulic conductivity of the aquifer. As a result, the estimated capture zone shown in Figure 1 is a lower bound of the actual capture zone of the pump-out system.

As shown in Figure 1, Monitoring Wells 1, 3, B, Q, S, and U lay within the estimated capture zone. Monitoring Wells V, W, X, and T are outside the estimated capture zone. Based on this result, Wells 1,3, B, S, and U which lay within the estimated capture zone, should be dropped from the monitoring network. Well V, W, X and T which are predicted to be outside the estimated capture zone, should be kept in the monitoring program. In addition, it is recommended to keep Well Q in the monitoring program, although it is predicted to be within the capture zone. Water quality monitoring at Well Q will provide information of the western lateral extent of the trichloroethylene plume.

The Proposed 1994-1999 Operations and Monitoring Plan presented Target Pumping Rates as well as Action Levels for the pump-out wells. The Target Pumping Rates are monthly average pumping rates that serve as a guideline for the operation of individual pump-out wells. The Action Levels are pumping rates that are used to trigger an assessment of the operational status of the well, and conduct of necessary repairs. The Proposed 1994-1999 Operations and Monitoring Plan proposed Action Levels of 20 gpm, 40 gpm, 80 gpm, 80 gpm, and 80 gpm, at Wells 109, 110, 111, 112, and 113, respectively. The SLAEM model was run with Wells 109, 110, 111, 112, and 113 pumping simultaneously at these pumping rates to assess the impact on the capture zone. The computed capture zone was similar to that presented in Figure 1. The above Action Levels are therefore satisfactory actions levels because they will trigger a corrective action while adequate groundwater capture is still ensured.

From an operational standpoint, these Action Levels can be considered as minimum operational pumping rates that will provide adequate capture zone. Each time a pumping rate drops below an Action Level, an action will be taken to correct the problem. The actual pumping rates will likely be higher than these

Action Levels pumping rates, and will therefore maintain an adequate capture zone.

Magnolia and Carimona Members of the Platteville Formation

The analysis of the effect of anisotropic conditions on the width of the capture zone of Magnolia pump-out wells MG-1 and MG-2 were analyzed in a prior technical memorandum (Barr, 1993).

This analysis evaluated principal components of the transmissivity tensor in the Magnolia Member of the Platteville Formation, and estimated the capture zone of Wells MG-1 and MG-2, each pumping at 95 gpm using SLAEM, under conditions of anisotropy in the Magnolia aquifer. The method is described in detail in the above memorandum.

The resulting capture zone is shown in Figure 2. As shown in Figure 2, Magnolia Monitoring Wells OO, VV, ZZ are located within the capture zone. Magnolia monitoring wells TT and QQ are located outside the capture zone.

Because of the pumping occurring in the Magnolia Member, a downward vertical hydraulic gradient occurs from the Carimona Member to the Magnolia Member. As a result, groundwater in the Carimona Member overlying the Magnolia pump-out wells capture zone are expected to be captured by Well MG-1 and MG-2, and the capture zone in the Carimona Member is expected to mimic that in the Magnolia Member.

Monitoring wells in the Carimona Member are shown in Figure 2 along with the Magnolia pump-out system capture zone. Monitoring Wells 11, 13, BB, RR, and WW are expected to be within the capture zone. Monitoring Wells SS and UU are expected to be at the downgradient edge of the capture zone. Monitoring Wells 8, 9, 10, and 12 are not expected to be captured by the pump-out system.

Based on the above result, Magnolia Wells OO, VV, ZZ and Carimona Wells 11, 13, BB, RR, and WW, which lay within the estimated capture zone, should be dropped from the monitoring network. Magnolia Monitoring Wells TT and QQ, and Carimona Monitoring Wells 8, 9, 10, and 12 which are predicted to be outside the estimated capture zone, should be kept in the monitoring program. In addition, it is recommended to keep Carimona Monitoring Wells SS and UU in the monitoring program, because these were shown to be at the downgradient edge of the capture zone.

Conclusions

Based on the above modeling results of the pump-out systems capture zone, the following recommendations are made:

- Glacial Drift aquifer Wells 1,3, B, S and U, which have been shown to lay within the estimated capture zone of the pump-out system, are recommended to be dropped from the water quality monitoring program. Well V, W, X and T which are predicted to be outside the estimated capture zone, should be kept in the monitoring program. In addition, it is recommended to keep Well Q in the monitoring program, although it is predicted to be within the capture zone. Monitoring of water quality at Well Q will provide information of the western lateral extent of the trichloroethylene plume.

- The Action Levels of 20 gpm, 40 gpm, 80 gpm, 80 gpm, and 80 gpm, at Wells 109, 110, 111, 112, and 113, respectively, as proposed in the Proposed 1994-1999 Operations and Monitoring Plan are adequate actions levels. They can trigger a corrective action while an adequate groundwater capture is still ensured.

- Based on the modeling results in the Magnolia Member, it is recommended to drop Magnolia Wells OO, VV, ZZ and Carimona Wells 11, 13, BB, RR, and WW, which lay within the estimated capture zone, from the water quality monitoring network. Magnolia Monitoring Wells TT and QQ, and Carimona Monitoring Wells 8, 9, 10 and 12, which are predicted to be outside the estimated capture zone, should be kept in the monitoring program. In addition, it is recommended to keep Carimona Monitoring Wells SS and UU in the monitoring program, because these were shown to be at the downgradient edge of the capture zone.

Monitoring wells in the Glacial Drift aquifer are shown in Figure 3. Monitoring wells in the Carimona and the Magnolia Members of the Platteville Formation are shown in Figures 4 and 5, respectively.

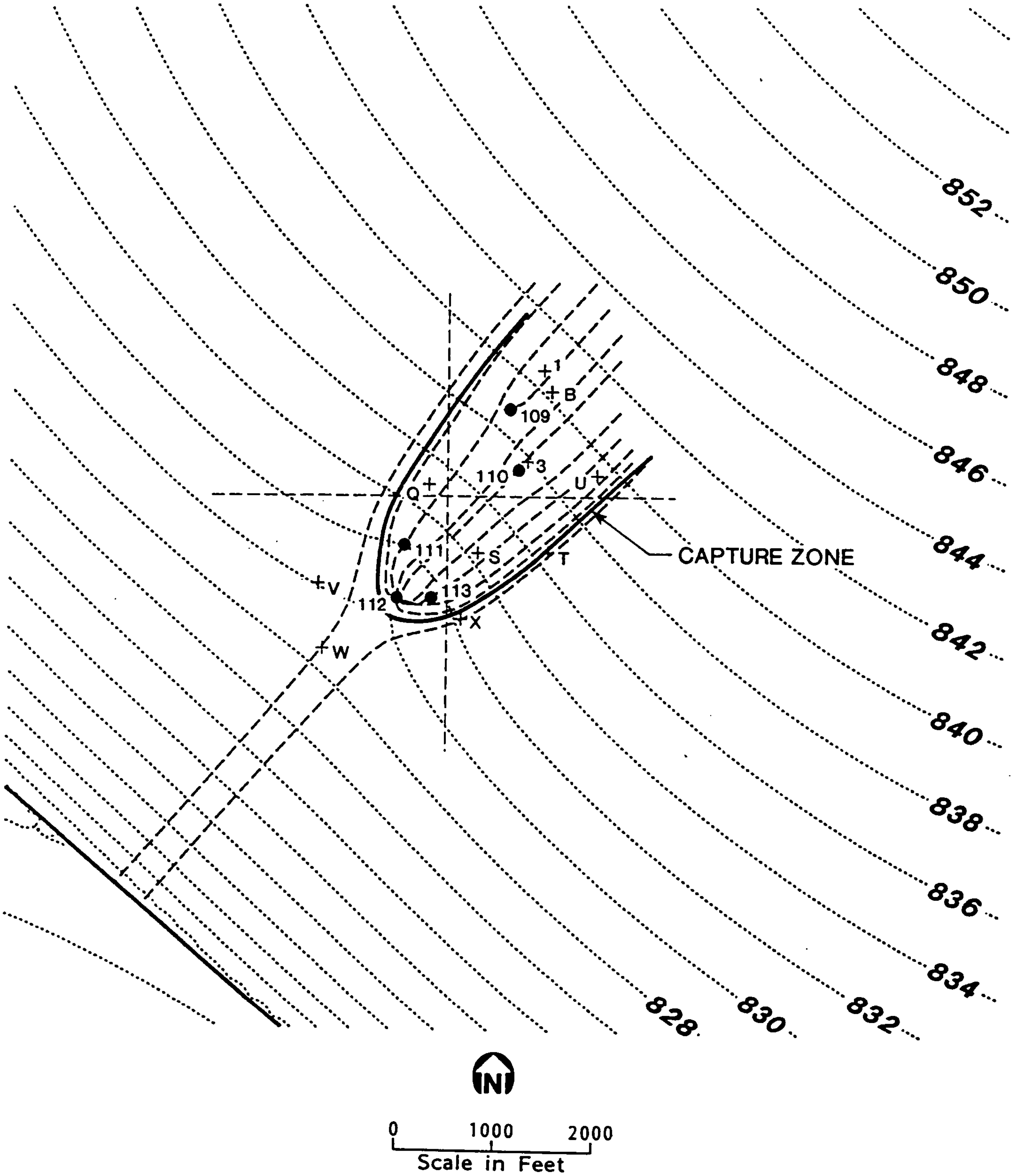
REFERENCES

Barr Engineering Co., 1983, Site Characterization Study and Remedial Action Plan, General Mills Solvent Disposal Site, 2010 East Henneppin Avenue, Minneapolis, Minnesota, Prepared for General Mills, Inc., June 1983.

Barr Engineering Co., 1985, Groundwater Pump-out System Plan, General Mills East Henneppin Avenue Site, Prepared for General Mills, Inc., January 1985.

Barr Engineering Co., 1993, 1992 Annual Report, East Henneppin Avenue Site, Minneapolis, Minnesota, Prepared for General Mills, Inc., January 1993.

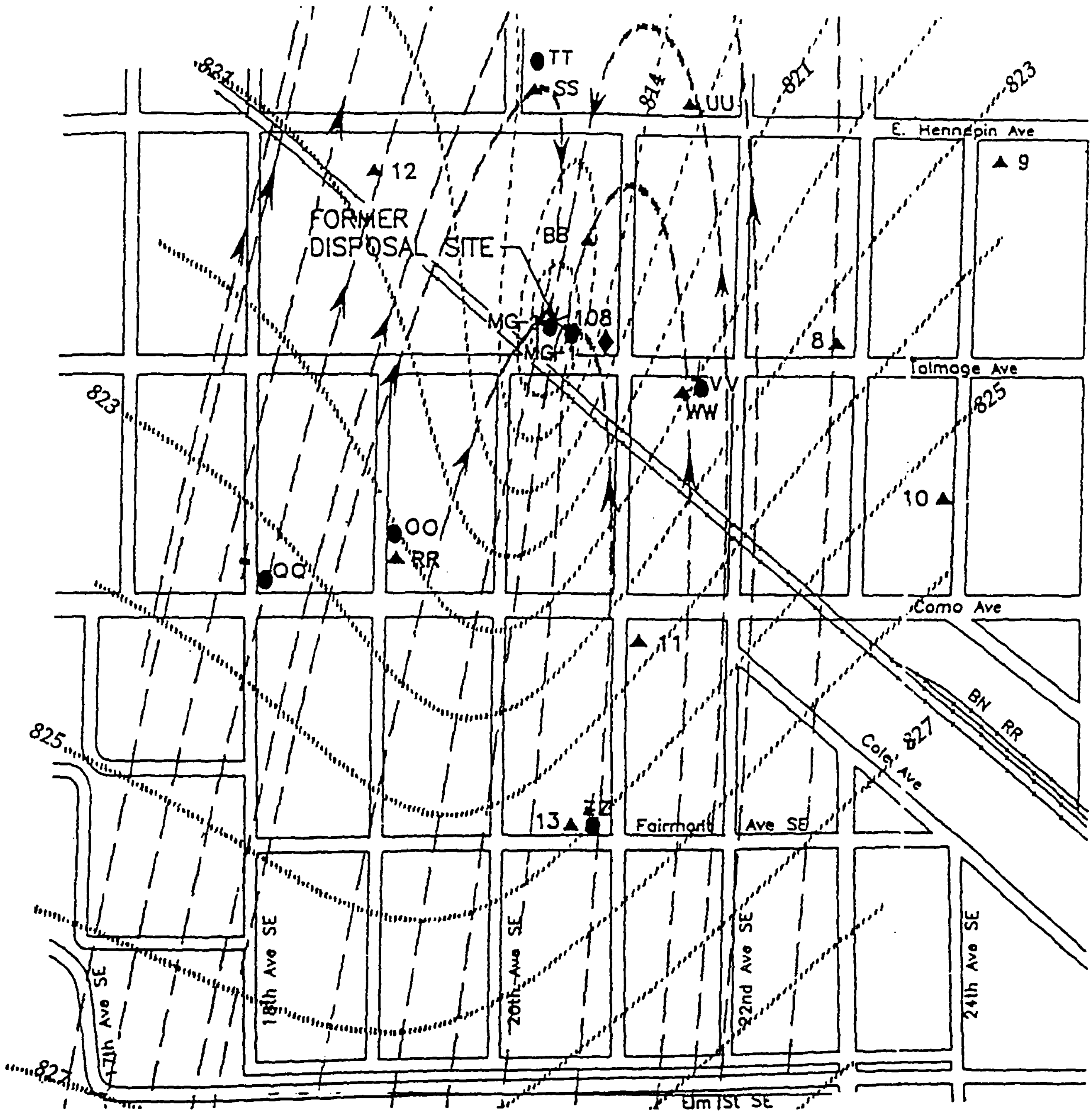
Barr Engineering Co., 1993, Technical Memorandum, Analysis of the Effect of Anisotropy on the Pump-out System Capture Zone, August 1993.



● Pump-Out Well

Figure 1

PREDICTED CAPTURE ZONE
IN THE GLACIAL DRIFT AQUIFER



● MAGNOLIA MONITORING WELLS

▲ CARIMONA MEMBER MONITORING WELL

◆ CARIMONA MEMBER PUMP-OUT WELL

0 200 400
SCALE IN FEET

Figure 2

SLAEM SIMULATION OF CAPTURE ZONE
OF MG-1 AND MG-2
EACH PUMPING AT 95 gpm

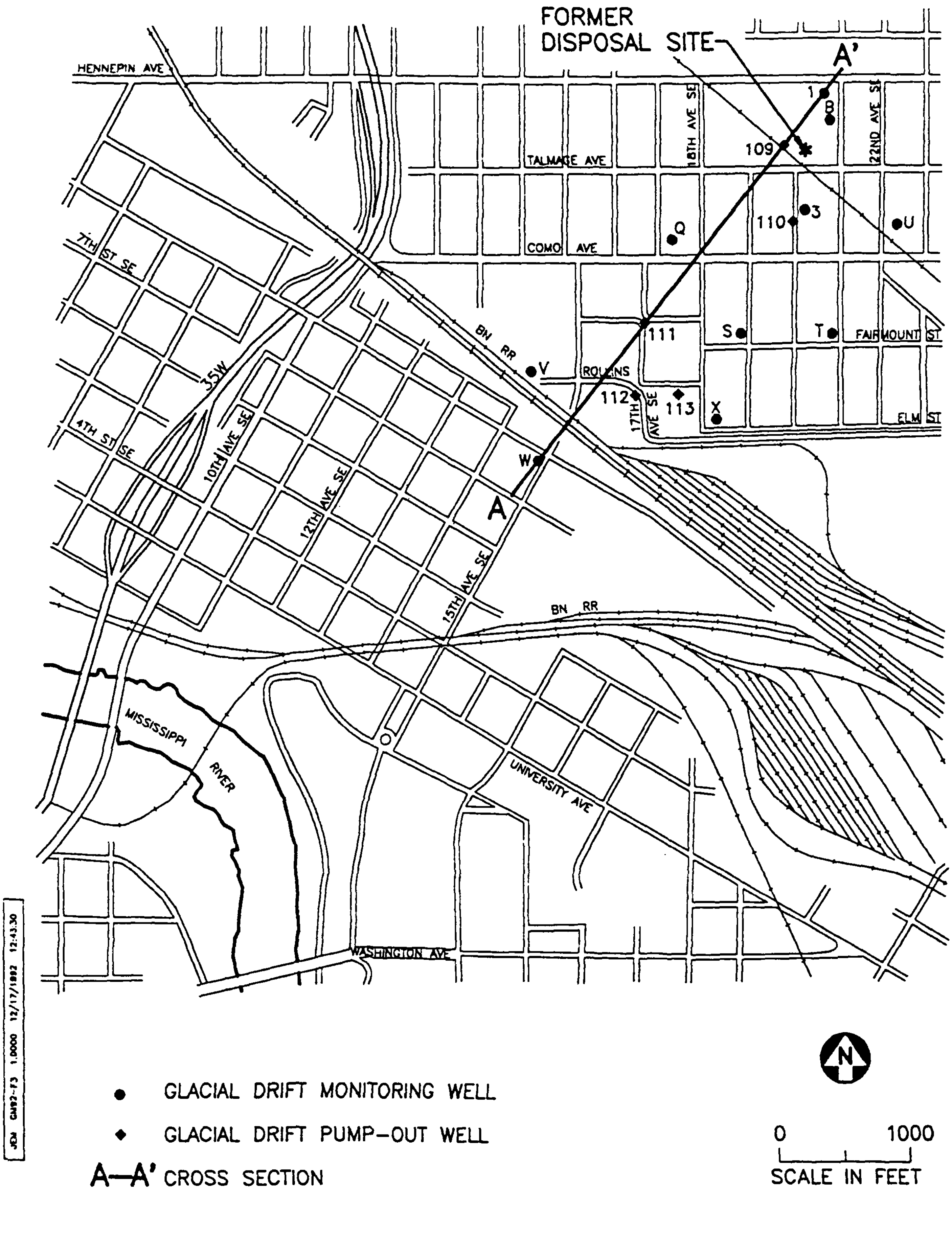


Figure 3

MONITORING WELL LOCATIONS
GLACIAL DRIFT

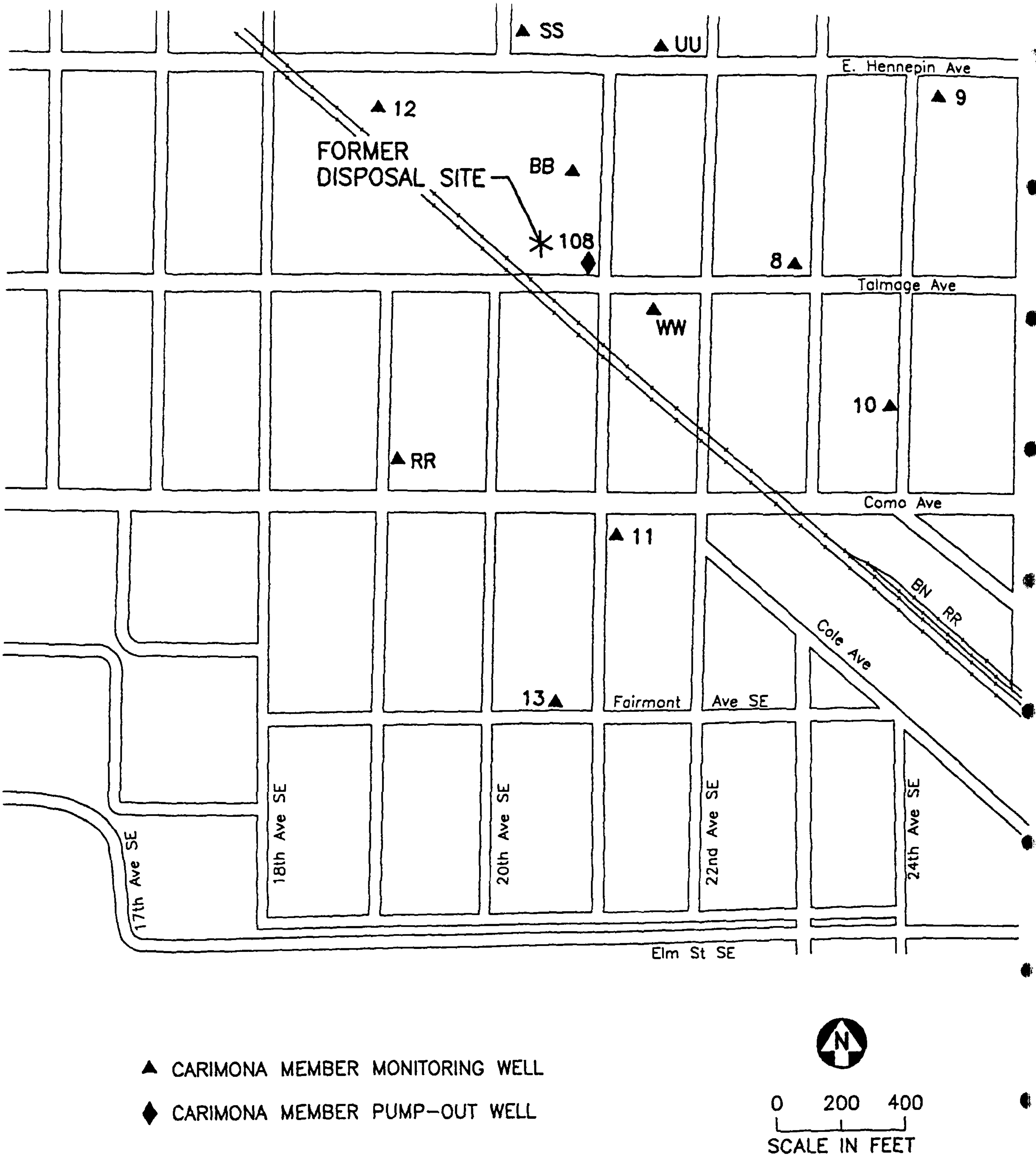


Figure 4

MONITORING WELL LOCATIONS
CARIMONA MEMBER

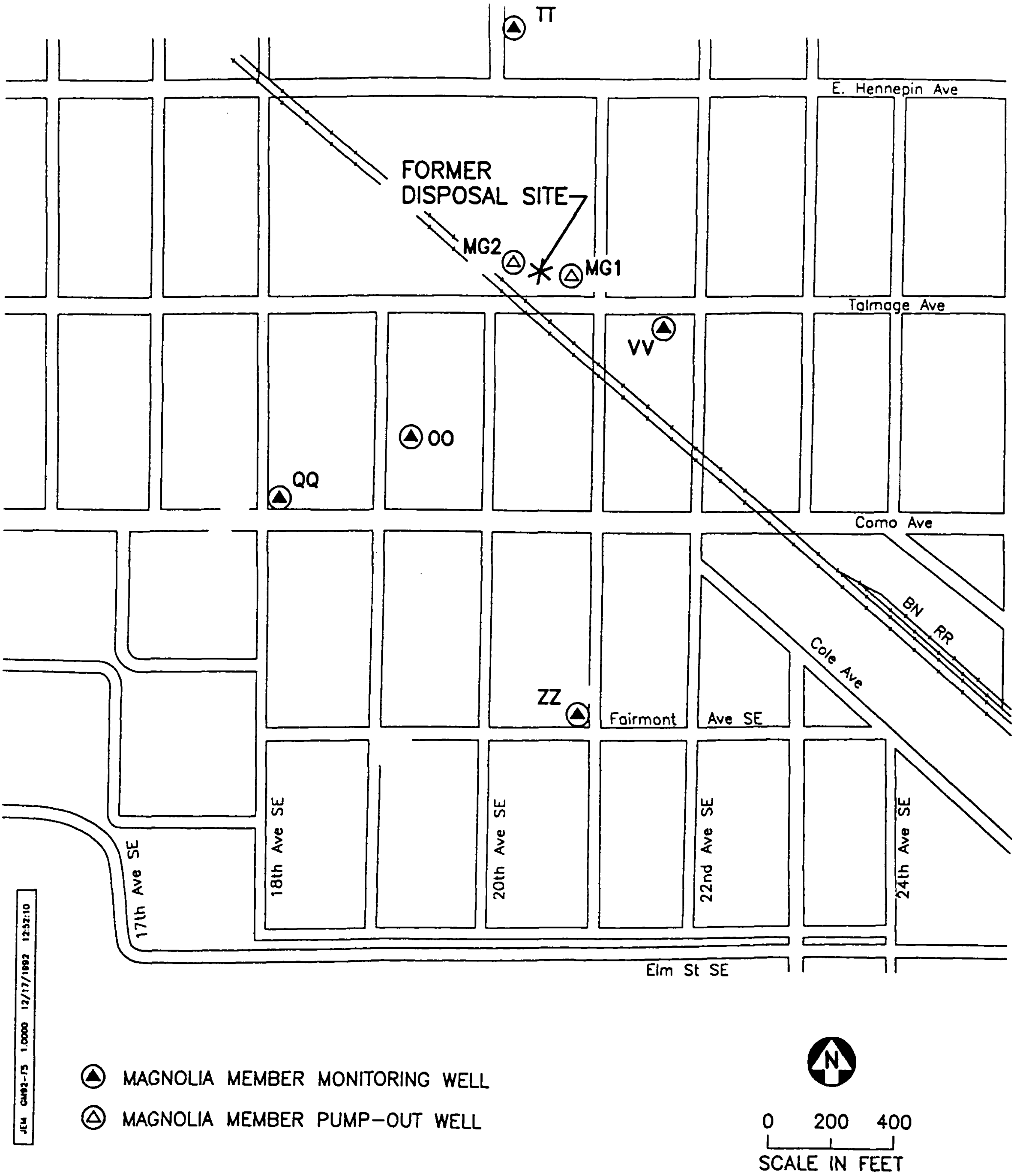


Figure 5

MONITORING WELL LOCATIONS
MAGNOLIA MEMBER

Attachment 1

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*                                                                             *
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*                                                                             *
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       reset
         yes
       win  0 0 10000 10000
       ref
          400 1800 810    *
       ret
       aqu
         perm  280    *  in ft/day - high K for conservative assumptions
         por    .25
         thick   1000 *  large thickness for unconfined conditions
         base     804 *  lowest base for conservative assumptions
       ret
       ret
       giv
         rain 0.00182 3000 3000 1 1
       ret
       ret
       map
         plot on
         point
           3144    3682 * W
           3094    4312 * V
           3890    4169 * 112
           4236    4178 * 113
           4545    3980 * X
           3964    4691 * 111
           4711    4623 * S
           5416    4635 * T
           4210    5297 * Q
           5113    5440 * 110
           5206    5521 * 3
           5902    5396 * U
           5020    6022 * 109
           5438    6197 * B
           5362    6400 * 1
         ret
       ret
     li
       head
       -8.87451E+03  9.56299E+03 1.05627E+04 -6.37451E+03   810
        5.56274E+03  1.51880E+04 1.50635E+04  7.31323E+03   860 *850
      com
      ret
     map
      plot on
       cur
          4390 7134    *  18TH AVE.
          4406 2699
```

```
    ret
    ret
  map
    cur
       2028 5169   *  COMO AVE.
       6684 5186
   ret
   ret
   map
    cur
       3000 2000   * 1000 feet scale
       4000 2000   * 1000 feet scale
    ret
    ret
swi
  back
```

```
***************************************************************************************
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*                                                                                     *
*                                 DRIFT AQUIFER                                       *
*                                                                                     *
*                                                                                     *
*                          DATA FILE NAME: GENMDR.WEL                                 *
*                                                                                     *
***************************************************************************************
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      ret
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         factor 192.48
         given
           5020    6022  45  * 109
           5113    5440  46  * 110
           3964    4691  91  * 111
           3890    4169 117  * 112
           4236    4178  69  * 113
         ret
      ret
      swi
        back
```